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FOREWORD

For the future of the local industry an important contribution in this number is that by Dr. James Anderson on the organization of community breeding of cattle. Of recent years many farmers in other countries have realized that it is essentially uneconomic for each man with a comparatively small herd to maintain his own bull. If several farmers club together they can afford between them to pay a higher price, get a better sire and eventually establish a reputation for local production of their chosen breed. Moreover the cost of replacing a bull is spread between them. This beneficial arrangement can be greatly extended in its scope by linking it with the practice of artificial insemination, already familiar in Kenya. Indeed in an area where the cow population is widely scattered community breeding will depend for its general adoption and for any full measure of success on the use of artificial insemination. In his article Dr. Anderson explains in detail how local schemes would be worked.

The subject of seed supplies of European vegetables has come very much to the fore of late and is assuming growing importance owing to the high price of seed and the increasing difficulty of obtaining normal supplies. In the past we have, wisely perhaps, been content to leave the growing of these seeds in the hands of the professional seed-growers of Europe, America and elsewhere, but the time has now come when we should seriously consider the possibility of producing our own. Just how far this is possible is still uncertain, for we have very little information to go on. Literature on the growth of European vegetables for seed in the tropics is almost non-existent; in fact very little in English, or any other language, has appeared on their growth even in temperate regions. For this reason we have thought it useful to prepare a compilation, printed in this number, of the scattered information on the subject. Although the article lays emphasis on the necessity for selecting plants which are true to type as seed parents, yet the opportunity should not be lost for selecting and isolating strains which show themselves more suited for East Africa. This is particularly important for our lowlands, where we need new varieties that will tolerate more heat and drought than our existing varieties, which were originally selected for their success under temperate conditions. Apart from performing a public service, a successful seed-grower will probably derive considerable personal satisfaction and, we hope, some profit from his venture. For the man or woman who is fitted for the work by temperament, inclination and ability, few enterprises offer more personal satisfaction than crop improvement.

Mr. Doughty's article on *Striga* introduces the subject of a pest of maize and millets in Tropical Africa that further south is already recognized as of major importance. Mr. Doughty's preliminary work indicates that the problem of finding resistant varieties is not likely to be easy. There is no doubt that in the future *Striga* will have to receive much more attention than the scanty list of references shows it to have had in the past.

Another possible means of improving the local supply of cereal foods is indicated by Mr. Elmer's article. It is not often that we can introduce our readers to a new crop for East Africa; such a thing is rare notwithstanding the layman's touching belief in the scientist's ability to produce new species of cultivated plants as by magic. Mr. Elmer shows that Quinoa, introduced from the mountains of South America, promises to be a useful subsidiary food crop in parts of our highlands. Its ability to tolerate high elevations, frost and low rainfall are strong recommendations, as are the relatively high amounts of fat and protein in the grain. The author wisely includes a description of methods for cooking Quinoa. Lack of such knowledge has not infrequently led to the damning of really promising new crops, for example, the soya bean.

ARTIFICIAL INSEMINATION AND COMMUNITY BREEDING OF CATTLE

By Dr. James Anderson, Naivasha Experimental Station, Department of Veterinary Services, Kenya

Within the last decade or so a considerable advance has been made in our knowledge of the processes of reproduction. Much of this recent information has already been put to practical use, since the study of genetics has thrown light on the inheritance of several characters of economic importance in animal production. There has, too, been a growing realization among dairy farmers that greater progress can be made in the breeding of milch cows if they are prepared to combine certain of their resources, as for example in the joint ownership of bulls, which enables better bulls to be made available to a greater number of farmers. More recently still, the advent of artificial insemination has enormously enlarged the possibilities in this direction, for one sire may now produce 1,000 or more calves a year. When use is made of a proved sire, with high records of milk and butterfat to his credit, the very great advantage that must accrue to the district in which he is operating will be obvious. A brief review of the development of community breeding schemes, bull associations, and the application of artificial insemination to community breeding, may help to focus attention on the possibilities of such development in Kenya. The details of the communal application of artificial insemination in Kenya are discussed more fully, as they are of direct concern to certain districts which are contemplating community breeding.

Community Breeding

In Europe it is common to find one breed predominating in a given locality. This is in contrast with America and other countries (including Kenya), where several breeds are often found in one small district; and it is usually accepted that the grouping of breeds into localities is one reason for the much higher average production of dairy cattle in Europe. In certain instances in Europe community breeding may have arisen as a natural development from this uniformity of breed, but in the main it has been brought about through organized effort (Eckles, 1939; Winters, 1939).

In general, as Eckles stated, the primary purpose of a community cattle-breeding organization is to promote the welfare of the community by the improvement and development of a certain breed, and by the establishment between its members of co-operation and cordial relations which will ensure the most successful economic results.

The first recorded step towards community breeding dates from 1763, when the importation to the Island of Jersey of breeding cattle other than Jerseys was prohibited.

In America, organized community breeding has met with great success. The Western Reserve Holstein-Friesian Association, started in 1905 at Burton, Ohio, was the first organized attempt at community breeding, and this association has had a most successful history, selling cattle to many parts of the world. The Waukesha County Guernsey Association, established in 1906, became one of America's most notable examples of community breeding, and from 1910–1914 the county's average butterfat production per cow increased by 100 lb. The New Salem Breeding Circuit for Holstein-Friesians is another community with an international reputation. As an example of results achieved, it is noteworthy that one herd of 17 cows, which at the outset averaged 132 lb. of butterfat, showed, after seven years of community breeding, an average of 427 lb. The economic potentialities of such schemes were early recognized, and by 1910 thirty similar organizations were operating in Wisconsin; by 1920 the number had increased to 160. Since then a great many other organizations have been formed, and according to Eckles the success they have achieved has depended largely upon the extent to which individuals have been willing to subordinate their own interests to those of the community.

There are many obvious advantages to be derived from community breeding. It is better to have one breed in a district than many, whether grades or pure breds; such a district gains a reputation for stock of that chosen breed, and buyers are attracted, for the range of selection is wide. The reputation of a district for high-class stock may be established by shows, sales, advertising in the agricultural press, and so on. In normal farming practice very limited use is made of pure-bred sires, and this is particularly the case with exceptionally good sires, whereas community breeding makes such sires available for a much greater

number of breeders. The cost of replacing the sire in a small herd is heavy, and a small herd usually cannot afford to pay a good price for a bull. With community breeding the exchange of sires is possible, the expense of replacing a sire is reduced, and the community can retain the use of exceptional sires. The probability that bulls of high transmitting ability will be recognized before it is too late to make good use of them is increased, because of the greater number of cows that are served. By having a common purpose—the promotion of their chosen breed—breeders quickly find that they have many things in common. Breeding methods, the value of proved sires, the progeny test, line breeding, inbreeding, pedigrees and the history of the breed are studied and discussed with mutual benefit. Another usual activity of a community organization is the establishment of milk-recording associations and the stimulation of official testing.

Bull Associations

Denmark has the distinction of having organized the first bull association. In America, three co-operative bull clubs were organized in Michigan in 1908, and by 1921 there were 153 bull associations in the United States.

A bull association includes all the advantages of community breeding as well as several others. The greatest advantage is that the association places a good pure-bred bull within the reach of every farmer, no matter how small the herd may be. Since the number of bulls in service is reduced, members gain the use of better bulls at a lower cost per farm. Winters refers to the experience of the Roland Co-operative Bull Association in Iowa. When the Association was started each farm had an average of $89 invested in a scrub bull; these bulls were sold and five pure-bred bulls bought at an average cost of $78 per member. Each member therefore had the use of a good pure-bred bull, with $11 in pocket, and only one bull had to be fed in place of three or four previously. The bull association makes line-breeding possible, which is conducive to uniformity, and when the bulls are being purchased this fact should be kept in mind. Bulls in these associations are bred to more cows than if they were used in single small herds, and accordingly have a greater opportunity to demonstrate their worth. They are kept in service for a longer period and proved sires are available to the community until old age.

The average number of farms in each bull association in the United States for 1918–1920 was 38, and each association jointly owned five bulls. The territory of a typical association would be divided into five sections, each with a bull, and the average number of cows per section would be 48. A bull would stay in one section for two years and would then be moved on to another section. Winters emphasizes that each farmer should be made to understand that the breed selected at the outset is not subject to change; the question of breed must therefore be gone into thoroughly when the association is started.

Artificial Insemination and Community Breeding

Artificial insemination was first applied on a large scale in Russia, and no doubt the collective organization of farming activities greatly facilitated its general adoption in that country. The lead was followed only slowly by other countries, and three or four years ago probably more cows were being artificially inseminated in Kenya than in any other country outside Russia. Since that time, artificial insemination has made rapid progress in many countries.

Where bull associations were in existence, the change-over to artificial insemination was easy. This was the case in Denmark, which was the first country in Europe, apart from Russia, to attempt the application of artificial insemination on a large scale. Through the courtesy of Professor Sörenson, the writer was able to inspect the working of the Danish scheme in 1939. The usual number of cows in the Danish Artificial Insemination Societies is from 1,200–3,000, and one or two bulls are owned by the Society. A veterinarian is responsible not only for the artificial insemination but also for the genital health of the cows and for the treatment of sterility. Farmers notify the veterinarian by telephone of cows on heat, and semen is transported to the farms where the insemination is made. This scheme appeared in 1939 to be working to the general satisfaction, and already there were in Denmark 20 self-supporting societies for artificial insemination. An interesting point is that, contrary to expectation, the pedigree bull trade had improved, probably because the societies were paying high prices for good sires.

In the United States, co-operative artificial insemination is rapidly becoming popular. The first breeding unit was started in 1937 in Minnesota on an experimental basis (Cole, 1939), and by December, 1938, three co-operative breeding units were in operation in

New Jersey (Perry and Bartlett, 1939). The first of the New Jersey Associations was farmed in May, 1938, with a veterinarian in charge, 102 dairymen entering 1,050 Holstein cows, and in October it was enlarged to include 186 dairy herds entering 1,830 Holstein and 350 Guernseys, with another veterinarian to help with the work. The second scheme, the South Jersey Breeding Unit, started in November, 1938, with 1,000 cows—600 Holsteins and 400 Guernseys, using two Holstein and two Guernsey bulls. Later, three bulls of each breed had to be used. In each of these groups at least one outstanding proved sire of each breed was used. In the first group two related proved sires were being used regularly about every third day, and in addition a line-bred young bull was held in service for a short time as a means of securing future proved sires of related lines.

In New York State two organizations have been operating since 1938, and it is planned to develop additional breeding centres. Wisconsin has two operating units, and Michigan, Missouri, Nebraska, California, Mississippi, Maine and other states are either operating units or working on problems of artificial insemination.

Under the plan usually followed in America, members are organized into a co-operative association. The association owns the bulls, and breeding is carried on by a trained technician employed by the association. The territory is limited usually to a 15-mile radius, and for the most effective operation a minimum of 1,000 cows is signed up. Well selected sires, preferably of outstanding proved merit, are used. Limited experience from several states has shown that a breeding efficiency comparable to natural breeding can be obtained (Horwood, Cole and Smiley, 1940).

It will be readily seen that co-operative breeding through the use of artificial insemination includes all the desirable features of the older methods, but offers many additional advantages. By means of careful selection and the breeding of family blood lines, whole communities may share the progeny of an outstanding bull which formerly could serve only some 50 cows per annum. Young sires can be evaluated early in life by using them on a few score of cows, after which they are retired until proved. If their progeny should prove unsatisfactory, no great harm will have been done, because it is unlikely that any member will have more than one or two daughters of the unproved animal. The genetic ability of sires for high production can, in this way, be measured very effectively in a short time. Serious genital diseases spread by bulls can be greatly reduced and eventually eliminated. The regular examination of cows for pregnancy should cause less delay in calvings, and the regular inspection of cows by the veterinarian should lessen the incidence of sterility. The regular microscopic examination of semen ensures that only sperm of the highest quality is used, with the consequent assurance of the maintenance of a high and consistent standard of fertility on the male side. Economically, artificial insemination offers the farmer the services of the best bulls at a cost usually lower than that of owning a mediocre sire on his own farm.

The Application of Artificial Insemination to Community Breeding in Kenya

Artificial insemination was first started in Kenya in 1935, and within a short time a relatively large number of cows were being bred in this way. Exact figures are not available, but it is probable that about 20,000 cows are now being artificially inseminated. The main reason for the rapid adoption of artificial insemination was the prevalence of a serious form of genital disease that is transmitted by the bull, and there is little doubt that the genetic and economic advantages of the method are not, even to-day, generally or adequately appreciated in Kenya.

So far, artificial insemination has been used solely by the farmer on his own farm, and very satisfactory results have been obtained. It is only within the last year or so that one or two farmers have considered or attempted the transport of semen from one farm to another. this method has considerable possibilities in Kenya provided it is carried out under expert supervision, with proper safeguards, although in America it is regarded with disfavour (Horwood, Cole and Smiley, 1940). When semen is distributed by the owner, the operator may not be properly trained in the technique, and since the owner of the sire profits directly by the volume of the business, abuses are apt to arise. The desirability of permitting such arrangements has already been questioned by some national breed associations on the ground that it may lead to inaccuracy in the registration of animals.

The third and perhaps the most valuable method of using artificial insemination, namely

on a communal basis, has not yet been put into operation in Kenya; but it is to the credit of the Kitale farmers that, recognizing the possibilities, they formed in September, 1941, on the advice of the Director of Veterinary Services, the Trans Nzoia Community Bull Scheme, which should be functioning shortly. This is the first scheme of its kind in Kenya, and the author is not aware that another one exists in the Colonies, or even in the British Empire.

There is little doubt that, in Kenya, considerable progress in cattle-breeding can be achieved by the adoption of artificial insemination on a communal basis; and there are several districts in which it offers possibilities. The method is no less applicable in Native Reserves, and the writer has on more than one occasion expressed the view that no great progress will be made in cattle breeding in these reserves until artificial insemination is adopted.

The Director of Veterinary Services, in a letter to the Chairman of the Trans Nzoia Farmers' Association in July, 1941, stated: "I believe that adoption of the Community Bull Scheme . . . . is, after the Cattle Cleansing Ordinance, going to be the most important single step in planning this development of the dairy industry. From the organization of a Co-operative or Assisted Bull Service Club a great many other useful services will spring; in fact, as I see it, the insemination station will, in a very short time, prove to be the focal point from which most of our departmental activities will radiate. Perhaps I can best make my point by giving you a summary of some of these activities as we hope and expect they will grow from this nucleus.

(*a*) *Insemination Service.*—The station will maintain bulls of one European breed (I hope one of the Channel Island breeds will be selected) and of the Indian Sahiwal breed, and it will be the intention to make use only of the highest quality sires. I should like to begin with *proved* sires of both breeds. The service will be under the direct control of the Veterinary Officer, and skilled native inseminators will, where necessary, transport and inject the sperm. Careful records will be kept at the station.

(*b*) *The Control of Diseases of the Reproductory System and the Maintenance of a high level of Fertility.*—All herds participating in the scheme will be regularly inspected with a view to early diagnosis of genital diseases, infectious or otherwise. The Veterinary Officer's task will be to reduce wastage from this cause to a minimum. Our object should be to obtain a calf every twelve months from every cow in the herd, with a lactation of 300 days and two months rest. Any cow that does not come into heat within 60 days of calving should be reported to the Veterinary Officer, who will examine the animal, and take the appropriate steps to induce oestrus. Any cow that fails to hold to three successive services will be examined and subjected to corrective treatment.

Herds infected with contagious vaginitis, or contagious abortion, will be under the closest supervision, and all the resources of modern laboratory technique will be employed in the control of these infections. Coupled with the work on fertility, a careful survey will be made of the incidence of the different types of mastitis.

(*c*) *Milk Recording.*—The Club will naturally wish to obtain the greatest possible amount of information as to the comparative performances of mothers and their daughters sired by the Station bulls, and with this object in view contributors to the scheme will be encouraged to record their herds wherever possible. Check-recording and butterfat testing can be carried out locally, and I see no reason why records so obtained should not be included in the official milk-recording scheme."

It was further suggested by the Director of Veterinary Services that, on the assumption that an initial capital of about £800 would be needed, and that Government might be prepared to subscribe pound for pound with the farmers up to, say, £400, the necessary support would be forthcoming if 40 members would subscribe £10 each. This money would be devoted to the purchase of bulls and equipment, and the erection of buildings. For the first year it was suggested that a charge of Sh. 1 should be made for each service, and that members of the scheme should pay motor-cycle allowance (probably 20 cents a mile would cover this expense) when it was necessary for a native inseminator to travel to the farm to inseminate cows. Under such a system a farmer with 50 cows, living 20 miles out, would, on the assumption that his cows received two inseminations per year, pay very

little more than the yearly insurance premium on an average pure-bred bull.

It has been found in certain tropical and sub-tropical parts of the world that high-grade cattle are less well adapted than low-grades to environmental conditions, particularly to high temperature. Since the widespread application of artificial insemination will offer great opportunities for improving productive capacity, progress will have to be carefully watched to ensure that the constitution of the stock is maintained. Much of the dairy industry in Kenya, however, is in districts not subject to harmful high temperatures. A discussion of this subject is available in a recent publication by Daubney (1942).

In practice, the working of an insemination scheme involves two distinct sets of operations, one on the subscriber's farm and one at the Station. On the farm, it is necessary to have an efficient method for the detection of cows on heat, some arrangement for notifying the bull station of semen required, and an organization for the reception of sperm and the prompt insemination of cows.

Detection of Heat.—Since the whole success of artificial insemination depends upon inseminating cows at the proper time during the oestrous cycle, it is imperative that cows on heat should be efficiently detected. The shortness of the heat period, the lowered intensity of the signs of heat, and the fact that cows in Kenya are usually out grazing on fairly extended range, all combine to make the detection of heat rather more difficult than it would be in temperate countries. The signs of oestrus will be discussed fully in the new edition of the bulletin on artificial insemination which will shortly be published. Here it is sufficient to draw attention to the importance of heat detection, and to note that the best and most reliable indications are the willingness of the cow to stand still when mounted by a bull or by other cows, and her own desire to jump other cows.

A vasectomised bull is the most satisfactory agent for the detection of a cow on heat. After the operation of vasectomy, the bull, while retaining all the desire and capabilities for coitus of the entire animal, cannot eject spermatozoa. An objection to the use of a vasectomised bull is that in a herd affected with venereal disease (vaginitis and epididymitis) he may spread the infection mechanically. It is recognized that this possibility exists, and in at least one instance such a mechanical spread of infection has been reported by a farmer; but experience suggests that in practice the risk is not very great. Several infected herds have used vasectomised bulls over a period of years and have maintained satisfactory birth rates. In one herd in which the use of such bulls was discontinued on account of the risk of spreading infection, it became necessary in a few months to revert to their use in order to restore the birth rate to a satisfactory level. It is possible that, for heavily infected herds, the Department may be able to introduce an alternative operation after which the teaser bull will be unable to infect the cows, even mechanically. But, for the ordinary herd, the use of vasectomised bulls is strongly recommended.

The period during which cows most frequently come on heat is from 6 to 9 a.m. From 9 a.m. to 3 p.m. there is a decrease in the frequency, but from 3 p.m. to 6 p.m. the number again arises. Some cows may begin their heat periods between 6 p.m. and midnight, and such animals may be off heat by the next morning, and their heat periods may therefore be overlooked unless special steps are taken to detect them. It is quite probable that in many instances the recorded lengthy intervals between successive heat periods are due to the missing of heat periods that occur during the night. Cows coming on heat during the night may be detected, failing direct observation, by the use of raddle on the vasectomised bull.

On one farm that has been under observation, cows are picked out by the vasectomised bulls at the morning and evening milkings, but they are inseminated only once, in the morning. It has been found that a percentage of cows picked out the previous day will conceive to insemination the following morning, although they are no longer on heat at that time.

Notification of Cows on Heat.—Notification of cows to be inseminated will be sent to the Breeding Centre by the quickest means, and for obvious reasons it is essential that as many morning notifications as possible should reach the Station by 9 a.m.

Reception of Semen.—Where the farms are situated at no great distance from the Breeding Centre, as they will be in Community Bull Schemes, semen will probably be dispatched by road. Semen may be collected from the Breeding Centre by the native who brings in notification of the cows on heat, and taken to the particular farm where the farmer will per-

form the insemination himself; or trained inseminators may be sent out on ordinary or motor bicycles from the Breeding Centre to the various farms. The most suitable method for any district can be developed on the spot.

Where the farms are some distance from the Breeding Centre a considerable time may elapse before the semen is received. It is impossible at present to state the permissible time limit, since it depends on the length of time a cow can be successfully impregnated after she has been detected on heat. For the present, however, it is suggested that 12–18 hours after the detection of the onset of heat in a cow can be regarded as the permissible time limit for insemination.

Insemination of Cows.—The actual insemination will be done either by the farmer himself or by trained inseminators employed by the Community Bull Association.

One highly important point is the identification of female animals. If there is any doubt about the identity of cows, records are, of course, useless. At the Experimental Station, Naivasha, ear-tags and branding fluid have not proved very successful and hot branding irons are now used. Horn brands are also quite satisfactory. Whatever system of branding is used, frequent inspection of the brands is necessary to ensure that they can still be read. If it can be avoided, it is wise as a rule not to use similar numbers preceded by different letters.

It is equally important that all calves to be raised should be permanently identified by prompt tattooing, ear-tagging, sketching of colour markings, ear-notching or some other serviceable system. Soon after the calf is born the name of the sire and dam should be recorded with the owner and the Community Bull Scheme. This procedure is necessary if a complete study of the ability of various sires to transmit productive ability and desirable type-characters is to be made, and this applies particularly to grade herds. Otherwise, from forgetfulness or an unsystematic method of keeping track of breeding and birth data, much valuable information may be lost.

Breeding Centre

Most of the work at the Breeding Centre will be of a technical nature, and details will be found in the publication on technique (Anderson, 1937). One very important aspect will be the keeping of adequate records as a check on the efficiency of the method. Here again, experience in the running of a Community Bull Scheme will indicate which records are necessary and the best way of keeping them. The records suggested below are based on those used at the Experimental Station.

1. *Daily Semen Book.*—This book shows, in separate columns, the bull used, dated and time of collection of semen, number of specimen of semen, volume of ejaculate, percentage of motility, concentration of spermatozoa, method of storage, farms to which semen is sent, and time of dispatch of semen.

2. *Insemination Certificate* (see Appendix).—This will be sent out in duplicate with the semen, one copy being retained by the farmer and one by the Breeding Centre after completion of entries.

Full and accurate breeding records for each farm must be kept at the Breeding Centre. These records will provide valuable data on breeding performance, fertility and sterility on different farms and in different districts. A card-index system provides the most satisfactory method of keeping these records, and the system will include (*a*) daily list, (*b*) annual list, and (*c*) experimental list.

The daily list is a card headed by the name of the bull, on which is entered the date of collection of semen, the number of the specimen of semen, particulars of age of semen, methods of storage and dilution, and the cows inseminated with this particular specimen. As cows return to the bull they are marked on this list, which will therefore show at a glance the current state of breeding to this bull.

The annual list contains a card for each cow in the herd or herds. Particulars of date of insemination, bull used and specimen of semen are entered on this card, which provides information on the breeding performance of each cow. The experimental list may be kept at the discretion of the officer in charge of the Bull Centre. It will contain particulars of the age of semen when used, degree of dilution, and any other particulars, knowledge of which appears likely to improve the future efficiency of the service. From experience it has been found easier to keep these records from day to day, rather than make them up at the end of long periods.

One other record used at the Experimental Station is the Monthly List, which indicates the total female strength (of breeding age) in each herd at the end of each month, deaths

and disposals of female animals of breeding age during the month, and causes thereof. This form will also contain particulars of all cows that calved and calving dates, and similar particulars about abortions. In a community scheme, a monthly list of this type should be submitted by each member of the scheme to the Breeding Centre. In addition to providing valuable information about wastage, it keeps the Breeding Centre regularly informed of the total breeding strength of the herd. This information will be of great assistance in checking the fertility of the herd as a whole, for in Kenya it is the large number of cows that are not bred or are bred infrequently which, in the absence of disease, reduces herd fertility. It will be convenient to issue such monthly lists in book form, particulars to be entered in duplicate with carbon, one copy being retained by the farmer and the other by the Breeding Centre.

The keeping of all these records may seem to involve a large amount of clerical work, but in practice it works very simply and with a minimum of labour. The labour involved will, of course, be increased in proportion to the number of farms involved, and it will probably be necessary to employ a clerk whose main job will be the keeping of records at the Insemination Station.

Insemination of Pedigree Cattle

Certain rules have been drawn up by the Committee of the East Africa Stud Book, governing the entry in the East Africa Stud Book of pedigree live stock, born as the result of artificial insemination. Unless these regulations are strictly observed, no breeder should be allowed to register in the East Africa Stud Book any calf born as a result of artificial insemination.

Copies of the Rules and Certificates can be obtained on application to the Editor, East Africa Stud Book, P.O. Box 671, Nairobi.

REFERENCES

Anderson, J. (1936).—*Emp. J. Exp. Agric.* 4, 186 and 198.
(1937).—*East Afric. Agric. J.*, Sept.
Cole, C. L. (1939).—Quart. Bull. Agric. Exp. Sta., Mich., 22, 18.
Daubney, R. (1942).—*East Afric. Agric. Jour.*, Jan.
Eckles, C. H. (1939).—*Dairy Cattle and Milk Production*, 3rd Ed., Macmillan Company, New York.
Horwood, R. E., Cole, C. L., and Smiley, E. S. (1940).—Quart. Bull. Agric. Exp. Sta., Mich., 22, 236.
Perry, E. J. and Bartlett J. W. (1939).—*Exp. Bull.*, 200, New Jersey State Coll. Agric. and Agric. Exp. Sta.
Winters, L. M., *Animal Breeding*, Chapman & Hall, Ltd., London (1939).

APPENDIX

INSEMINATION CERTIFICATE

(*This Certificate to be sent out in duplicate with sperm, one copy being retained by the farmer and one by the Bull Centre.*)

I hereby certify that on .... (insert date) I collected semen Specimen No. ......) from (insert breed) .... pure-bred bull (insert name of bull) .... and that this semen (specimen No. ....) was packed by me and sent to (insert name and address of farmer)

....

....

(*Signed*) ....

Date ....

Particulars to be added by farmer or his agent:—

I hereby certify that on (insert date and time) .... I received the above semen (specimen No. ....) and that it was used *(*a*) by me, (*b*) by my agent, or (*c*) by the Community Inseminator to inseminate the following heifers and and cows:—

Name and/or No. of cow.	Date and time when first found on heat.	Time of Insemination.

(*Signed*) ....

Date ....

*Delete whichever is inapplicable.

(*Received for publication on 20th April, 1942*)

COPRA AS A PIG FEED

In view of the fact that copra has been advocated in some overseas papers as a high protein supplement for pig-feeding, it is desired to warn farmers of the advisability of proceeding with great caution in any experiments that they may wish to make. Two pounds of copra contain more than a pint of oil, and too high a percentage of copra in the diet may lead to scour. The high percentage of oil may also lead to too rapid fattening and the production of an inferior carcass.

The protein of the coco-nut is of relatively low biological value, and coco-nut products alone should never be used to balance the protein ratio of maize. Copra-cake has been used with success in pig rations when the ration has included lucerne or good grazing as an additional source of protein.

Kenya Veterinary Department.

TSETSE-FLIES AND DEVELOPMENT IN KENYA COLONY

PART II

By E. Aneurin Lewis, M.Sc., Ph.D., Entomologist, Veterinary Research Laboratory, Kabete, Kenya

TSETSE-FLIES AND STOCK

The conditions in Kenya Colony are, on the whole, more favourable to stock or mixed farming than to intensive cultivation, and there are a large number of cattle in the European areas and in the native reserves. The measure of success achieved in the treatment, or prevention, of some of the major diseases of stock has contributed to an improvement in the annual increase of farm animals, and farmers who at first relied entirely on crop production have either taken to stock on account of the unsuitability of the land for continuous crop growing or have been advised to adopt mixed or dairy farming. In some of these cases the multiplication of cattle has overreached the carrying capacity of the farm, and additional grazing in the vicinity of fly-belts has been utilized with disastrous losses from trypanosomiasis.

The natives, it is well known, consider stock as visible wealth and a form of currency. A large number of beasts of an indifferent type and condition may be a primary consideration, but it is not always correct to say that the natives do not concern themselves with the quality and that they do not make full use of the milk and manure. Natives near fly-belts often complain that they are unable to keep cattle and thus obtain the milk necessary for their children and the aged people. They allow their cattle, sheep and goats to feed on the harvested plots, and in this way endeavour to collect the manure for the land. When they do possess cattle they like to have large numbers because, they say, there is a greater chance of some surviving an outbreak of disease than if the herds were small. This, of course, applies to other stock diseases also, but one has met with the view more frequently in fly areas. It is an attitude difficult to condemn in the absence of facilities to remedy the fly situation. The natives are at present unable to check the tsetses or reclaim the infested land without assistance and supervision. The flies take a toll of the cattle and the natives are forced to retire.

The treatment of animal trypanosomiasis is effective only when the animals are not exposed to reinfection. The cattle cannot be concentrated in small areas suitable for the settlement of human beings, and their movements cannot so satisfactorily be controlled. The cattle wander in search of grazing and are more liable to roam into the fly-bush and become reinfected, and there is yet no medicinal means of preventive inoculation against animal trypanosomiasis.

The incidence of sleeping-sickness has been reduced by therapeutic treatment in most countries, but animal trypanosomiasis seems to be as prevalent as ever, and remains a problem of importance. *G. palpalis* and *G. swynnertoni* are the vectors of the disease to humans and to animals. They are restricted to parts of the Kavirondo and the Masai reserves. Other species of tsetse in the Colony do not transmit sleeping-sickness but they carry the trypanosomes of stock and are widely distributed. The tsetse-fly problem in Kenya is therefore mainly a cattle one.

Reference will be made later to the part played by cattle in assisting the dispersal of tsetses. Here it may emphasized that the movement of stock is influenced by the distribution of the flies. It has already been noted that the fly-belts are not always continuous, and that in some areas considered generally as infested there are localities where cattle, sheep and goats can graze with comparative safety from fly. The natives seem to be acquainted with many of these, and they appear to know when the flies retreat to the sheltered haunts, thus allowing a relatively safe route by which the stock can cross the fly-belt and move from one fly-belt locality to another. Native traders are able to take mobs of cattle from the East Uaso Nyiro, across that infested river and several fords of the Tana River, to Lamu and other parts of the coast. Some of the animals, it is known, contract trypanosomiasis, but a large number survive and arrive at their destination in good condition. Full information and detailed surveys of these established routes would be of great value. Slight improvements and adjustments might further reduce the risk of infection and provide a safe passage for all stock. Subsidiary routes could, perhaps, make the collecting area wider, and assist in the development of the stock industry for internal improvement and for export.

The presence of fly and the existence of animal trypanosomiasis have been recorded in districts where later investigations proved the

unsuitability of the districts for tsetse infestation. In the earlier days the term "fly" was indiscriminately used for the disease and for the insect. It is certain that many of the records made during the last war, for example, refer to the disease diagnosed at remount camps or animal transport depots. The disease had been contracted weeks or months previously when the animals were passing through a fly-belt in another district. So, in later years, work-oxen purchased in the vicinity of fly-belts or which had been driven through a strip of tsetse-country died on fly-free farms. Examination of blood smears revealed the trypanosomes, perhaps after the beast had died from another disease. Latent parasites appear in the blood when the host has been weakened through overwork or any other strain.

On the other hand, deaths from trypanosomiasis may occur regularly or periodically in a locality where brief surveys have failed to prove the existence of tsetses. Repeated searches have ultimately produced a few flies that have spread unexpectedly from a distant fly-belt, or there may have been a small focus previously undiscovered. It has been observed that a single *G. pallidipes*, a restless feeder, may fly from one beast to another, and bite several animals before obtaining a satifactory meal. With each bite an infected fly will transfer the trypanosomes to the animal. In this way many of the stock contract the disease in what at first appeared to be a fly-free area.

Again, outbreaks of trypanosomiasis have resulted from watering animals at known fly-infested rivers or other sources of water, when extreme drought compelled the herdsman to utilize these places despite the presence of fly. Or it may be that such a watering-place, hitherto considered safe at certain seasons, had been invaded by flies dispersing at an unusual time of the year.

Tsetse-flies and Water Supplies

The brief notes on the distribution of the tsetse species in Kenya show that *G. brevipalpis, G. fuscipleuris, G. palpalis* and *G. pallidipes* are intimately associated with forest and thicket near water, and they are most often found in valleys, along river courses, on the shores of lakes and at the sea coast. *G. austeni* inhabits the good rainfall districts and the broken forest of the coastal province. *G. swynnertoni* is less dependent on water and moist climate, but in Kenya it occurs in greatest abundance in savanna woodland and fairly thicketed country not far from river-beds. *G. longipennis* has been reported to be still less dependent on water. Recent observations by the writer coincide with those of Anderson, who collected this species near water in the neighbourhood of the South Uaso Nyiro. Large numbers of *G. longipennis* were lately found close to the Kiboko River, between Makindu and Simba, and although breeding-places were discovered throughout the drier thorn-tree country, many were also located within a few hundred yards of river-beds.

Most of the large rivers in the Colony harbour one or more species of tsetse-fly. They are not infested from source to mouth. The upper reaches in the European highlands are usually free, and the flies infest those stretches which pass through native country and unalienated land. The tributaries serve as lines of further dispersal, and many have become permanent habitats of the flies. In some alienated areas occupied by Europeans the tsetses have spread up-river and threaten the future of the stock or dairy farming in those places.

Although the river valleys form the stronghold of the majority if not all of the tsetses in Kenya, nearly all the species contrive at some time to occupy much of the adjoining country, and *G. pallidipes, G. swynnertoni, G. brevipalpis,* and *G. austeni* are able to establish themselves near isolated waterholes.

The use of these natural surface sources of water is therefore restricted. Consequently, there is a heavy demand on other watering-places in fly-free areas, also applications for additional bore-holes, tanks and dams. Such centres are visited by stock from all directions, and like a much-frequented river-ford form points from which radiate numerous deeply worn tracks liable to erosion.

In Kavirondo corridors have been made across some rivers to enable natives to collect water or to cross with safety from *G. palpalis*. Other larger patches of bush infested with *G. palpalis, G. brevipalpis* and *G. pallidipes* have been isolated by cleared barriers, the flies have been reduced or eliminated by the catching-out method, and long stretches of the rivers thereby rendererd available to man and animals.

Some fly-infested valleys are poorly supplied with surface water. The river-beds have nearly disappeared because of siltation over a long period, and springs are scarce or without a sufficient output of water. Pools appear in the bed of the river during the rains and last for a few months afterwards. Bore-holes appear to be impracticable, and the construction of dams is considered merely a temporary expedient.

The Lambwe Valley in South Kavirondo presents difficulties of this kind. A series of experiments on the control of *G. pallidipes* in this valley resulted incidentally in the reclamation of about 30 square miles of land and not less than eight miles of "river" front. Only about one-tenth of the indigenous bush was destroyed; a few abandoned water-holes and dams were cleared out and renovated, and a number of new dams constructed.

An objection to projects of fly eradication in such areas as this has been put forward on the ground that the elimination of the tsetses would still leave the country uninhabitable because of the lack of water. It has been said that the natives will not occupy the land for that reason. This is of course true, but the history of the Lambwe and a survey of the old native watering-places throughout the valley indicate the need for following up the tsetse-fly control by the development of water supplies. It is sound to say that unless the flies are first driven out, the provision of water would be useless, or at least a constant source of danger to stock. The abandonment or neglect of these so-called "waterless" localities also means the possible extension of the fly-belts, the invasion of new territory and the probable loss of more watering-places outside the original belt.

The situation in the drier, fly-infested thorn-tree country and the savannas is much the same. A reasonable amount of water could be provided in some parts of these areas in more or less the same way as it has been done in plains country. Tanks constructed in the Osero or Aitong localities of the Masai Reserve have had to be abandoned because no provision was made to check the advance of *G. pallidipes* and *G. swynnertoni* in the area. No improvement of water supplies alone will ameliorate the conditions for stock in fly-infested areas.

Fly Dispersal and Advance

The natural tendency of tsetses to increase, disperse and occupy new country is closely associated with development and with protection of indigenous fauna and flora in their original state.

Unaided Spread

Tsetse-flies spread over country adjoining their permanent haunts in search of food. The young and the hungry flies disperse more widely and fly to greater distances than others. Spontaneous movement and advance may also result from an increase in the fly-density in a given area, provided that a suitable habitat exists within the fly's range. The season has a considerable influence on the expansion and contraction of the area infested.

There is not much concrete evidence of this automatic and unaided spread of the tsetses in Kenya, except for seasonal dispersals. The advance of *G. swynnertoni* and *G. pallidipes* in the Osero district of the Masai Reserve appears to have been spontaneous. It may, however, have been associated with the movements of game or Masai stock. Vehicular traffic cannot be held to be responsible. *G. pallidipes*, *G. brevipalpis* and *G. longipennis* in the Keiti Valley and Nzaui location of the Machakos district have gained much additional territory in the last twenty years, and it is suspected that the construction of a road through the old fly-belt has contributed to the advance of the flies in this area. Reports have also been received from the coast of stock having to retreat from advancing flies, and it appears that *G. palpalis* and *G. pallidipes* have encroached on additional locations in Central Kavirondo. As in the cases of seasonal dispersal on the border farms of the Highlands, the main lines of fly movement are the rivers and valleys.

Certain species, it may be noted, are most active and hunt over a wider area at dusk, at night, or before sunrise. This may be emphasized because of its special importance in these days, and more particularly because many people concerned with transport still believe that it is safe to travel through fly-belts after dark.

Spread assisted by Cattle

Swynnerton (1936), discussing the invasion of country by tsetses, stated that, next to flies' own movement, native cattle are probably the greatest spreaders of tsetse, in Tanganyika at any rate. Cattle along beaten tracks not only carry flies some distance beyond the fly area but leave a trail of scent which the flies follow spontaneously. When the traffic of stock is heavy, large numbers of flies are assisted out of the belt and carried possibly to a suitable site, where gradually they become established. It has been observed that *G. pallidipes* is especially attracted to cattle, and that even in the absence of these animals it makes frequent use of old tracks and paths.

Spread aided by Road Traffic

The construction of roads through fly-belts offers greater facilities for the movement and dispersal of tsetses, and moving objects in the

form of man, cattle, cars and lorries increase the opportunities for widespread infestation. Swynnerton wrote, "When the Shinyanga-Mwanza road ran through a fly-belt, flies (*G. swynnertoni*) were carried in fifties and hundreds to forty miles and more into the open country to the north by numerous lorries and cars daily." The road from the Tanganyika border to Barkitabuk in the Kenya Masai Reserve passes through a wide area of *swynnertoni-pallidipes* country, and specimens of flies are transported by lorries and cars from the edge of the belt, five miles west of Barkitabuk, to the river ford in the township. The situation in the Keiti Valley has undoubtedly deteriorated since the making of the "famine" road from Makindu to Nziu. *G. longipennis,* in particular, has moved many miles up the road. This fly is evidently attracted to moving vehicles at night, and may take advantage of transport travelling at night from Mombasa to up-country towns. Other instances of motor vehicles carrying flies are more familiar: on the roads from Mombasa to Voi, from Mombasa to Malindi, and on the Shimba Hills; from Lolgorien and the Gori River area towards Kisii; from Port Victoria to Luambwa in Central Kavirondo; and from Marsabit to Isiolo in the Northern Frontier Province. What will be the effect of the increased traffic and the larger number of roads for military operations is of course unknown, but it may warrant close attention.

There are also a number of roads or well-worn car and lorry tracks in the fly areas of Kenya. Many of these have fallen into disuse and have been replaced by others. The older tracks through bush and forest still provide easy passage for flies. It would appear advisable, under these circumstances, to consider carefully the alignment of roads built for purposes of opening up the Colony, and to consider the dangers of aggravating the fly situation.

Spread assisted by Railway Traffic

Passengers on trains from Mombasa are aware of the part played by this form of traffic in attracting and carrying tsetse-flies. Specimens of *G. longipennis* especially are taken inland, sometimes for considerable distances. Isolated flies have been collected at Nairobi, and even as far as Naivasha, and many specimens have been captured in European compartments from Makindu to Kiu. Recently a much larger number of *G. longipennis* was observed in native carriages in which, apparently, the windows are either left open or there is no gauze screen to prevent the flies from reaching the attractive light at night.

A few cases of animal trypanosomiasis in the Kima-Sultan Hamud-Emali section appear to have been due to flies transported by trains, and there is some evidence that the "pocket" of *G. pallidipes* on the railway side of Emali (Olmundus) Hill has been reinforced by flies carried in or on trains.

Again quoting an opinion from Tanganyika, ". . . railroads and motor roads passing through actual fly country into potential fly country are at least a very great danger."

The influence of game and man on fly dispersal will be dealt with in conjunction with a review of the methods of fly control.

The Need for Tsetse-fly Control in Kenya

The adoption of a comprehensive scheme for the control of tsetse-flies depends upon the requirements of economic development, the protection of the people and agricultural communities, the rate of progress and expansion, and the tendency of the inhabitants to respond to the urge of improving production and their mode of living. The support of administrative, professional and advisory officers is frequently if not always necessary, so that measures to cope with the flies do not affect other, perhaps equally important, interests.

Many requests have been received for advice on measures to reduce tsetse infestation in different alienated areas. The recommendations have usually been to create protective barriers across the lines of actual and potential fronts of fly dispersal. The execution of the suggested clearings usually falls to individuals whose farms are nearest to the fly-belt, and whose finances are perhaps already depleted through losses due to animal trypanosomiasis, drought, or the failure of crops. The farms adjoin native reserves, and it is often controversial as to who should undertake the clearing and who should bear the cost. It is interesting to note a reference to these borderland farms in the evidence by a Provincial Commissioner before the Carter Land Commission (1933): ". . . . It has been a condition that special development is applied to certain farms; for instance, where there is suspected 'fly'.

"I am prepared even to say that if private enterprise is not prepared to take up such farms and develop them, I should like to see Government take them up and develop them in some form, possibly in connexion with the reserve

for growing fodder crops, and by some means have these farms definitely and effectually under development."

The general idea of developing these border farms would fit in with the prevention of fly dispersal and advance in such areas as Sultan Hamud, Mitubiri, Makuyu, and the Maragua; the Ol Arabel Valley and Subukia, Muhoroni, and Miwani, and at the coast and possibly elsewhere.

The natives in most parts of the Colony infested with tsetses are desirous of protecting their land which is now free, and anxious to reclaim that which has already been lost on account of fly advance. Applications, approved and supported by the local administrative officers, have come from many locations: the local native councils of South and Central Kavirondo, from Turkana, Masai, Ukamba, and several areas on the coast. Usually, the application is supported by offers of financial contributions and free communal labour; others, in the hope of Government assistance or grants from the Colonial Development Fund. These fly areas in native reserves are often so extensive and the continuation of material support so uncertain that it is difficult to undertake the work with an assurance that it will proceed to an extent satisfactory to any of the parties interested. On the one hand, the officers responsible for the expenditure of native money require a guarantee that results of practical utility will accrue, and that they should be more or less commensurate with the costs. On the other hand, the technical officers unable to obtain accurate information based on up-to-date and carefully compiled surveys, or without sufficient knowledge of the habits and adaptability of the different species, hesitate to commit themselves to irrevocable assurances. The need for staff to carry out the necessary accurate surveys, not only of the distribution of the fly, but of the vegetation, the terrain and the agricultural possibilities of the areas, is an important one as far as tsetse-fly eradication is concerned; and in order to consolidate reclamation and ensure development. It is to be borne in mind, however, that the fly situation in all localities may change, and that reclamation should therefore proceed soon after investigations with that end in view have been carried out.

Dealing with the problem of tsetse-flies in a chapter entitled "Scientific Research and its Neglect," A. G. Church (1927) said, "Reference has been made already to the imperative need for combating the tsetse-fly menace to tropical Africa; . . . Nearly two-thirds of the potentially fertile areas of Tanganyika are under its domination. Northern Rhodesia and Nyasaland are almost equally unfortunate, while it is an ever-present source of anxiety to the Uganda and Kenya Governments."

In the Report of the East Africa Commission (1925), it is suggested among other points that "experts be appointed to carry out a complete survey of the fly areas in tropical Africa, to carry on research, particularly with regard to the physical conditions influencing the numbers of fly, to experiment on a field scale with regard to extermination, and to study the treatment of both sleeping sickness and animal trypanosomiasis. Meanwhile the several local Governments should press forward the work of extermination, making local surveys and such scientific investigations as may be possible, arranging for co-operation between the various Government services, and enlisting the assistance of the public, both European and native."

The Carter Land Commission reported: "The prevalence of tsetse-fly, carrying trypanosomiasis in cattle over large areas of many of the native reserves, is an important factor in connexion with overstocking. Such areas contain much valuable grazing land (as well as agricultural land) which cannot be used for depasturing cattle, while there is over-concentration of stock in other parts of the reserves."

"Bush-clearing for the eradication of fly would do much to ease the overstocking problem, would render available further extensive areas of grazing, and so enable other parts of the reserves to be rested."

"We recommend that an extensive campaign for the clearing of fly-infested areas be undertaken, and that measures which, we understand, have met with considerable success in Tanganyika Territory, be studied."

A year or so before the Carter Land Commission Report was issued, a grant had been received from the Colonial Development Fund for the purposes of carrying out a series of field experiments on the control of *G. palpalis* in a mixed fly area in South and in Central Kavirondo, and of *G. pallidipes* in the Lambwe Valley.

Advised and assisted in the preliminary stages by the late C. F. M. Swynnerton, Director of Tsetse Research, Tanganyika, and his officers, valuable information on the habits and reactions of the tsetses was obtained. The spread of the flies in certain directions was arrested, and reasonably large areas of useful land were reclaimed. Additional sums of money were

readily voted by the Local Native Council, and, in 1937, a further grant for the continuation of the experiments to discover whether the cattle tsetse, *G. pallidipes,* could be controlled by the use of fly-traps and without clearing all the indigenous bush. These experiments or field trials have proved beneficial not only in South Kavirondo but also for the control of *G. pallidipes* and other species in different districts. Unfortunately, schemes drawn up have not been adopted because of lack of financial support or need for staff and labour.

The methods which other territories have employed against the species of tsetses with which they are chiefly concerned have been studied, and the interchange of reports, literature and ideas have been of considerable assistance in devising means to attack the important species in Kenya Colony.

The following brief review of measures under trial and those that have been adopted in other territories will show the importance attached to research, to the pursuance of available means to control and exterminate flies, to reclaim land, and to disturb as little as possible those other conditions that affect the welfare of the people and the development of the areas concerned.

Methods of Fly Control

Perhaps the earliest method was to remove the people *en masse* from an area where *G. palpalis* caused epidemics of sleeping-sickness. Such evacuations were recorded in nearly all the tsetse-infested countries. The natives left of their own accord, or were advised for health reasons to do so by the Administration.

The clearing of woods and thickets was also employed as a means of protecting settlements, wells and springs, riverine watering-places, fords and landing-places against *G. palpalis.*

Narrow strip clearings along rivers, roads and other routes of travel were, for many years, considered to furnish some degree of immunity from the attacks of tsetse.

Other recommendations included the destruction of the bush only where it was believed the tsetses retreated and concentrated in the dry seasons, and which they seemed to favour as breeding-places.

Some observers were of the opinion that the destruction of the wild mammals, the larger reptiles, etc., would contribute to the reduction and starvation of the tsetse-flies. Others considered it inadvisable and even dangerous to contemplate control of the fly through depriving it of food through the slaughter or expulsion of its wild hosts, for if the fly could not thus obtain food it would be more likely to attack man and his domestic stock.

Hand Catching

The collecting of flies with the aid of a hand net, very much like that used for catching butterflies, was practised in order to obtain specimens to study and ascertain the species involved when fly surveys were carried out. It seemed a slow process for the purposes of extermination, for it was not then fully realized that not all species of tsetse appeared readily to man. Different scent attractants were tried, and adhesive substances to simulate the popular household flypaper were used on cloths or sheets of paper worn by natives. On the Island of Principé, in the Gulf of Guinea, it was recorded, many thousands of *G. palpalis* were trapped in this manner, and within a few years it was claimed that this, with measures of prophylaxis, was successful in virtually exterminating *G. palpalis.* Similar efforts with adhesive substances in other territories against this species and other tsetses were not satisfactory.

Swynnerton designed and introduced a T-shaped screen made of hessian or other cloth slung under a pole and carried on the shoulders of two boys who were supplied with hand nets. He found the screens to be far more attractive to the female flies than the boys themselves. but did not specify whether all species were attracted to the same extent. Symes and Vane (1937) report on the screens as of no value against *G. palpalis* in Kavirondo, and the writer has not been very successful in collecting large numbers of *G. swynnertoni, G. palpalis, G. brevipalpis,* and *G. fuscipleuris* with screens. Different kinds of colours of cloths have been used, and the only species of fly against which any sort of screen has, so far, been really useful in Kenya is *G. pallidipes.* A variety of scent-baits have been applied to screens, and experiments have been carried out with wet, damp and dry cloths. In some districts and at certain seasons, the dark-brown screens have proved as successful as the use of bait-oxen, and have always been more attractive than man. It is of interest to note that Austen and Bagshawe (1914) suggested the use of limed cloths, of nets in the hands of expert fly-boys, and the testing of traps. The tests, they add, should be carried out in a selected locality for at least a year, and on a large scale.

Cattle have, of course, been employed in collecting most species, and have been of great value in country infested with *G. brevipalpis, G. fuscipleuris, G. pallidipes,* and *G. austeni.*

(To be continued)

VEGETABLE SEED GROWING IN EAST AFRICA

By A. G. G. Hill, B.A., Agr.B., B.Sc.

The main sources of our vegetable seed supplies in the past, Europe and America, having become uncertain and seed expensive, the question now arises whether we can produce our own seed, thus ensuring future supplies and at the same time reducing imports. This is a difficult question to answer, for information on the raising of European vegetable seeds in the tropics is extremely meagre and no fresh information of any account has come to hand since that published in this Journal in May, 1940. There is no doubt of our ability to produce seed of beans, peas, lettuce and tomatoes, but can we produce seed of beet, cabbage, carrot, cauliflower, parsnip, onion and turnip?

Vegetable seed growing on a large scale is not an undertaking to be entered upon lightly for it is a specialized business requiring particular knowledge and skill. It has become specialized and localized to such an extent abroad that certain districts, where soil and climate have been found particularly favourable, were, until recently, relied upon to supply requirements almost throughout the world. It is unlikely that any one district of East Africa will be found suitable for seed production of more than a few kinds of European vegetables, but this can only be determined by experiment.

A good seed-growing district usually has a cool sunny climate and low total annual rainfall but plenty of moisture during the growing season. Certain parts of the East African highlands would fulfil these conditions, but it is doubtful whether our temperatures are sufficiently low to stimulate flowering in some of the Brassicas, one of the most important groups of European vegetables. Again, certain crops, such as the onion, require a definite minimum length of daylight to bring them to maturity. This period varies with the variety, and although the Bombay type of onion will seed in parts of East Africa, it is doubtful whether other varieties will do so. But against these drawbacks it may be found that East Africa has certain advantages over temperate regions. For instance, it may be possible to raise seed of biennials in one year instead of the normal two. Another advantage is the practical certainty of dry harvests.

The following general information on seed growing in temperate countries has been compiled from available literature with the object of assisting those who propose attempting to raise their own seed or to take up seed growing on a large scale. It is not pretended that it will serve as a sure and comprehensive guide to seed growing in East Africa, where it is almost certain that modifications of standard practice will have to be evolved. Seed growing is a subject in itself and one can do no more here than point out the main points that must be considered before undertaking the work, which should be begun on a small scale. In any case, prospective growers should first seek advice from their Department of Agriculture and find out what the market prospects are for local or export sales.

Vegetable crops in general are of two kinds, (*a*) those which are self-pollinated and (*b*) those which are, or must be, cross-pollinated. To grow seed of self-pollinated crops is comparatively easy, provided one begins with a pure seed stock, keeps the plants free from diseases and pests and weeds out any aberrant forms or rogues. Examples of class (*a*) are peas, beans and tomatoes, and natural crossing is so low in these crops that, even if no precautions are taken against it, no serious damage is likely to occur in the first generation. However, most of our vegetable crops belong to class (*b*) and are subject to cross-pollination, namely beet, cabbage, carrot, cauliflower, celery, cucumber, kale, kohl-rabi, leek, marrow, onion, parsnip, pumpkin, squash, turnip, radish and spinach. Unless a grower is prepared to take the necessary precautions to prevent indiscriminate crossing, he will be wise to avoid trying to grow seed of cross-pollinating crops. In such crops the purity of varieties is maintained by isolating the seed plots, so that the outbreeding or crossing is limited to the interbreeding of the different plants within a variety. If out-breeding is not controlled in this way the good qualities of a variety will be lost and replaced by a mixture of mongrel types. Without precise knowledge of local conditions it is impossible to say what distance must separate different varieties to guard against contamination by crossing. This distance, which may be as much as a mile in the case of cabbage, will depend partly on whether pollination is effected by wind (as in beet) or by insects (as in cabbage and marrow). Where only a few insect-pollinated plants are grown for seed, contamination may be more severe and may even come from a greater distance than when a crop is grown for seed on a large

scale. This is because a mass of flowers, by attracting and keeping the bees in one area, gives a more effective isolation than distance, unless that distance be very great. Besides looking to one's own crops it is essential to find out what cross-pollinating crops are flowering on neighbouring lands.

Crossing often produces increased vigour in plants, a phenomenon which is exploited by professional seed growers, but amateurs would be well advised to avoid intentional crossing with the object of trying to produce hybrid vigour. If the amateur wants to experiment, he should concentrate on the search for desirable variants with the object of discovering new and better varieties of European vegetables for the tropics. Such selection should be harvested and sown separately for further trial.

Only the best commercial varieties should be grown as parent plants, unless the grower has improved varieties of his own, and it is wisest for him to concentrate on a single variety of each crop unless he can isolate each one safely. The seed grower must be highly critical and absolutely ruthless when selecting parent material in the field, though it is sometimes permissible to make allowances for unfavourable conditions such as bad patches of soil, poor cultivation or bad season. Only the best plants, true to the required type, should be allowed to flower and seed. On no account should all the best vegetables be sold or eaten and the survivors left for seed. Nor should one collect seed from a few plants which may be the only ones to seed at the end of the season, for in this way one may be unconsciously selecting for late maturity, usually an undesirable character in vegetables for the tropics.

When in flower most vegetables need support and should be tied to stakes. They also need plenty of room; even a radish may need three to four square feet.

The following brief descriptions are given of the methods used abroad when growing the following crops for seed:—

Brassica Crops

Seed production in this group, which includes cabbage, cauliflower, kale, brussels sprouts and turnips, is best in cool climates where these plants normally behave as biennials. In the tropics, those that flower[1] may produce seed in one year. With these biennials it is usual to transplant the selected parent plants in their second year after a period of winter storage, but in East Africa, provided growth conditions allow, transplanting could take place immediately. As an alternative to transplanting, parent plants could be left in the ground until they bloom, provided the rest of the crop is uprooted before flowering. Owing to the danger of cross-pollination it is essential that no attempt should be made to grow a number of Brassica varieties or types in a limited area. All those Brassicas with the wild cabbage as their ancestor can pollinate each other, thus giving rise to nondescript and useless hybrids. A seed plot should be at least half a mile from other varieties of Brassicas. However, if only a small quantity of seed is wanted it is possible to avoid this trouble by enclosing a small group of parent plants in an insect-proof enclosure of fine muslin. The flowers of these enclosed plants will have to be hand-pollinated since they are largely self-sterile. Selfing in Brassicas usually results in loss of vigour.

Cabbage.—Although reported as seeding in East Africa it is rather doubtful whether sufficiently low temperatures prevail, even in our highest areas, to ensure successful seed production.

Select parents from fully developed plants, transplant these at 24 inches each way and cover to the base of the main leaves. Later, mould up to encourage the development of the flower-stalk and prevent wind damage. Transplanting can be avoided and selected plants allowed in flower in situ if all unselected plants are removed before they flower. A good cabbage head is so solid that the flowering stalk may not be able to break through unless the head of the cabbage is cut cross-wise fairly deeply and the sectors torn apart. Cabbage grown under sufficiently cold conditions will produce seed from the axillary sprouts that develop after the head is cut. Cabbage seed is harvested when the pods show signs of shattering. Dry the pods in trays and thresh with a flail, or a threshing machine adjusted as necessary. Clean the seed by screening and then dry again before storing.

Cauliflower.—Two distinct types are grown in East Africa, the tropical and the European. Both are reported to produce seed here, the former in the lowlands and the latter in the highlands. Select as parent plants those with fully-formed curds and cut the remaining plants before they flower. If the curd shows signs of rotting in wet weather scoop out the centre with a sharp knife to admit light and

[1] So far as is known, kale and brussels sprouts do not flower in East Africa.

air. After flowering, the seed pods should be allowed to ripen on the plant as long as possible. When they are yellow, dry and brittle and on the point of splitting open, cut them off branch by branch and lay them on a sheet in a dry place. Later the seed can be rubbed or beaten out and screened. Dry thoroughly before storing.

Turnips.—Reported as seeding in East Africa. Only roots of the best shape should be selected as parents. Consideration should also be given to colour, size, early maturity and amount of top. Some turnips produce an excess of top and very little root. The selected mother-roots can be transplanted after trimming the tops to another plot, or left in situ, in which case all unselected plants should be uprooted. Crossing will take place between turnip varieties but not between turnips and cabbage or cauliflower. The harvesting and preparation of the seed is much the same as with the other Brassicas described above.

Beans and Peas

Since seed of these is already grown successfully in East Africa, little need be said about them except to emphasize the necessity for preserving trueness to type by discarding all rogues or off-types. Most varieties of beans and peas are not to any extent subject to cross-fertilization, therefore multiplication plots of the different varieties need not be widely separated. The pods should be left until fully ripe before harvesting. If pulled early in the morning, when the dew is still on them, they are less likely to shatter. Dry the pods until quite hard before shelling. It is particularly important to avoid infection by bean-weevils (see Storage).

Carrot, Parsnip and Celery

Carrot.—Will seed in East Africa. The crop develops normally at medium temperatures (60°–70°F.). Isolate the seed plot from other carrot varieties. Sow seed for mother-roots[1] in drills about ½ inch deep and 12–28 inches apart. (With rows 18 inches apart approximately 4 lb. of seed is needed per acre). Reject all roots that are light in colour and without a well-formed neck, as well as those with deformed or forked roots. A well-formed cortex and a thin core are desirable characters. An idea of the cortex may be gained by cutting cores from a few of the apparently ideal types. The planting and after-care of these selected mother-roots is the same as for beet (*q.v.*).

Since carrot seed ripens unevenly, seed clusters should, if labour permits, be harvested as they ripen and turn brown. Otherwise, harvest the crop when the majority of the clusters are ripe, cutting the seed stalks low down and tying them in bundles of three or four. These are stooked until shrunken and seasoned, or they may be hung in an open shed to dry and mature. Handle as little as possible to prevent shedding. When removing the crop from the field load into hessian-lined baskets from ground-sheets. Threshing can be done in an ordinary thresher, adjusted as necessary, or, if the crop is small, by beating the heads in sacks. Another method is to spread the heads thinly on a sheet until thoroughly dry and then to run a roller over them. This method works only on hot days. Avoid breaking the stalks during threshing as the bits are difficult to separate from the seed. Clean the seed by screening and winnowing. Unless the beards are removed from the seeds by rubbing through screens after drying, trouble will be experienced in sowing through the seeds clinging together in balls. A special machine, with two endless belts running in contact but in opposite directions, is made for removing the beards. Seeds should be carefully dried after threshing; a drying kiln may be necessary in damp weather. Yields of carrot seed average 400 to 500 lb. per acre in Europe.

Parsnip.—Reported to seed in Kenya. Cultivation for seed is similar to carrot and beet. Select as parents those roots which are true to type, having a pale smooth skin as free as possible from coarse fleshy side roots. Harvesting of roots should begin as soon as the stalks are seen to be drying and changing colour and the individual fruits begin to split in half. The central cluster, or umbel, ripens its seed well in advance of the remaining ones and has to be cut first. If labour allows, it is better to cut each umbel as it ripens, otherwise choose a time when the greater part of the seed is ready, or nearly so, and cut down the whole flower-stem and dry indoors. Thresh seed and dry thoroughly before storing. Parsnip seed rapidly loses its viability in storage.

Celery.—Reported to seed in Kenya. Celery will flower under a wide range of day lengths, provided that the temperature is favourable for

[1] If mother-roots are wanted immediately from which to raise seed as soon as possible, these might be selected and bought at market, if none are available from elsewhere. They will not grow, however, if over-trimmed top and bottom. Beet, parsnip, onions and celery might be purchased in the same way.

the initiation and development of flowers. Exposure of seedlings to relatively low temperatures has been shown to increase the number of plants that seed. Select plants which are true to type and transplant them with only their roots in the ground and not earthed up. The seed clusters ripen successively, like those of the parsnip, the ripening being indicated by a change in colour of the seed and stem from green to brown. Harvest as in the case of parsnips.

Beet and Spinach

Beet.—This crop is reported to seed in East Africa. The seed plot must be isolated from spinach-beet as well as from other beet varieties in flower. Seed for the raising of mother-roots is sown 15 inches apart. (5 lb. of seed per acre is required for this.) Roots from this crop are selected for trueness to type and while still immature are harvested for subsequent transplanting, which may be done immediately or after a period of storage, depending on growing conditions at the time. All roots showing coarse leaves or roots, rough corky tops, abnormally numerous leaves or excessively branching roots are rejected. The internal quality should also be tested, by removing a core, and roots showing any zoning discarded. The selected mother-roots are replanted in the field after trimming back the leaves to the growing point, care being taken not to damage this. One method of transplanting is in furrows three feet apart, the young roots being pressed into the side of the furrow 18–24 inches apart with the growing point just above ground-level. To avoid shattering, the crop is harvested when two-thirds of the seeds are beginning to turn brown. Plants are harvested with a sickle, bundled and stooked until cured, afterwards being stacked under cover for threshing.

Spinach[1].—A long-day plant, but reported to seed in the tropics. Male and female flowers are usually borne on separate plants, although in some strains the plants bear both male and female flowers. Only one variety should be grown for seed unless the seed plots can be widely separated, say half a mile apart. Pollen is distributed by wind and insects. The simplest way of selecting parent plants is to uproot all those plants which do not reach the desired standard of quality, and leave the rest to seed. The seed develops very unevenly and harvesting is carried out by collecting and storing the heads in paper bags until the seed is properly dry, when it can be threshed, winnowed and dried.

Cucurbits

Most kinds seed readily in East Africa. Each variety should be segregated to prevent crossing. In-breeding generally has no harmful effect on cucurbits; conversely, crossing apparently does not result in hybrid vigour. Select the most desirable types and allow them to mature on the vine. Pumpkins, cucumbers and melons have separate male and female flowers and it is often necessary to pollinate by hand to obtain effective seed setting. Seed can be cleaned by fermenting (see Tomatoes).

Miscellaneous Vegetables

Onion.—Certain varieties will seed in parts of the tropics. Onion varieties have a rather strict regional adaptation and will not produce normal bulbs unless they have a definite length of daylight. Thus, one variety will do this with a short day of 12 hours, while another may demand 13½ hours. The crop normally likes a cool, moist climate during the growing period, with warm, dry weather for maturing and seeding. Irrigation is an advantage. The onion is normally cross-fertilized and selfing results in deterioration. The flowers are extremely popular with bees, flies and other insects and care must be taken not to grow more than one onion variety for seed unless each can be well isolated. When choosing parent bulbs in the field for seed production, select for early maturity, good shape (whether flat, round or apple-shaped) and resistance to diseases and pests. Well-ripened bulbs only should be selected; the thick-necked ones which have not completed their growth should be discarded. These mother bulbs are usually stored before replanting to test their keeping qualities, but if growth conditions permit they can be left in the ground until they flower, provided that the rest of the crop is uprooted before flowering. A considerable time elapses between flowering and the ripening of the seed. The correct time to harvest the heads is when the seed has reached the dough stage and is no longer milky. The seed darkens early, but this is no indication of maturity. Cut the heads with a short piece of stalk attached and dry on a sheet. Too rapid drying adversely effects germination. Two or three pickings may be necessary. If the weather is bad, the ripening stalks can be cut off near ground level as soon as the seed is black and laid thinly in a dry, airy but shady place to season. The dried heads are roughly threshed on the drying sheets and the screened seed poured into water. The first-grade settles on the bottom, leaving

[1] i.e. *Spinacia oleracea*, not New Zealand spinach, which usually seeds like a weed in the tropics.

on top the second-grade, which is useful for thick sowing for spring or pickling onions. The seed is then thoroughly dried. Unless stored under really dry conditions onion seed rapidly loses its vitality.

Lettuce.—This is a long-day plant, which therefore might be expected not to flower in the tropics, but it flowers and seeds in East Africa only too readily. Although an open-pollinated plant, very little crossing normally takes place in the field. However, if pure seed stocks are being raised it is necessary to protect the flowers from any possible contamination by pollen of other lettuce varieties. For seed production choose vigorous, mature plants with well-developed heads and remove all others before they flower. Long standing is one of the most important criteria of excellence, particularly in the tropics. Plants for seed production should be grown and selected during the cool months, since summer heat adversely affects flowering and seed production. It may be necessary to open the enclosing leaves of firm-headed types to assist the flower-stalk to emerge. The flowering period is protracted so that there may be flowers and seed on the same plant. Ripening of the seed is indicated by the appearance of a puff of down ("pappus") which replaces the yellow floret. Ripe seed is blown away by the wind unless harvested at once. When only a few plants are grown in the garden, the ripe seed may be harvested branch by branch or the head may be bagged. If this is impossible, cut the stems when the greater part of the seed on the plant appears to be ready to shell out. Lay these on a cloth in the shade under cover to complete the ripening. Do not wait until the seed is ripe on the latest branches, for by then the first, and best, batch will have been blown away. Threshing and cleaning lettuce seed is a somewhat tedious business.

Tomatoes.—Seed production in East Africa should present no difficulties. Natural crossing is low with this crop and little serious damage is likely at first even if no precautions are taken against crossing. If only a small quantity of seed is required this can be collected with a spoon from fully ripe fruit of selected plants, the seed being spread on blotting paper to dry. If large quantities of seed are required the whole fruits should be crushed and the mass fermented, without water, in a cask or pan for a day or two with frequent stirring. The skin and pulp will then separate from the seeds which will settle at the bottom. The seeds should then be washed, spread on trays and stirred regularly until dry. Over-fermenting will discolour the seed and probably spoil germination. Eggplant seeds can be separated from their pulp in the same way.

Radish.—Reported to seed in Kenya. Varieties of all colours and shapes will pollinate with one another, consequently they must be grown well apart. Roots of the best shape and colour, which mature early and have the smallest tops, should be selected as mother roots. Transplant these, or leave in their original plot after discarding all unselected roots. Late roots left in the bed after all the earliest and best have been selected, or eaten, are not fit for seed production. There is no danger of radish seed shattering when ripe. It is difficult to thresh.

Seed Storage

The methods advocated for seed storage in temperate regions are usually not applicable to the tropics, where storage pests, combined with higher temperature and humidity, create their own problems. At Amani (rainfall 77 inches) it has been found that seeds are best kept in large airtight containers with a small quantity of powdered naphthaline mixed with the seed. In the tropics really thorough drying of seed is necessary before storage, preferably in a special seed-drying oven—a pyrethrum-dryer might be modified for the purpose. Small quantities of seeds can be stored for surprisingly long periods if kept in calcium chloride desiccators in a reasonably cool place.

Particular attention is necessary in some districts to prevent damage by Bean Weevils, which lay their eggs on the pods, in field or store, so that tiny grubs emerge and bore their way into the seeds, making holes no larger than a pinpoint. These grubs develop in three or four weeks into adult weevils, which emerge making the characteristic holes indicative of weevily beans. The pest is controlled by planting weevil-free seed, harvesting the crop as soon as ripe, fumigation and storage in weevil-free buildings. Fumigation can be carried out in airtight containers, using half a pint of carbon bisulphide or four pints of petrol for each 100 cubic feet of storage space.

BIBLIOGRAPHY CONSULTED

L. H. Bailey.—*The Standard Cyclopœdia of Horticulture*, Macmillan Co., N.Y., 1937.

D. Boyes.—Veg. Seed for the Garden, *Hort. Educ. Assoc. Occ. Pub.*, Apr., 1941.

Cox & Starr.—*Seed Production and Marketing*, John Wiley, N.Y., 1927.

M. B. Crane.—Seed and Food in War-time, *J.R. Hort. Soc.*, 65 (10) 321., Oct., 1940.

W. V. Harris.—Bean Weevils, *Ento. Series Pamph.* 2, *Dept. Agr., Tanganyika*.
A. G. Hill.—*E. Afr. Agr. Jour.*, 5 (6) 476, May, 1940. *J. Dept. Agr. S. Australia*, May, 1941, 577.
T. B. McClelland.—*J. Agr. Res.* 37 (10) 603, 1928.
Ochse & de Jong.—Europeesche Groenten, Volkslectuur, Batavia-Centrum, Serie 490, 3rd Ed., 1932. (Part translation kindly provided by Imp. Bur. of Hort. & Plantation Crops, E. Malling.)
A. C. Orman.—Seeds of Root Crops, *Agr. Gaz. N.S.W.*, 52 (12) 621., Dec. 1, 1941.
G. J. A. Terra.—Onion Growing in the Tropics, *Landbouw*, 12th Taargang, 1936, 131.
P. H. Thomas.—Production and Selection of Veg. Seeds, *Tasmanian J. Agr.*, 12 (4) 142, Nov. 1, 1941.
Prod. of Root & Veg. Seeds, *J. Dept. Agr. Eire*, 38 (2) 355, Sept., 1941.
U.S. Dept. Agr. Year Book, 1937.
Seed Growing in Great Britain, *J. Min. Agr. England*, 26 (3) 318, June, 1919.
Thompson.—*Vegetable Crops* (Chap. 7), McGraw-Hill.
H. C. Thompson.—Effect of temp. and length of day on growth of Veg., Hort. Abst. 11 (1), Abs. 93, Mar., 1941.

PETROL AS A GRAIN FUMIGANT

Some time ago the following letter was received from Capt. E. F. Peck, Deputy Chief Veterinary Officer, Somaliland Protectorate:—

"The article by Mr. Wilkinson in your October, 1941, issue prompts me to relate a recent experience in weevil control. I have tried many substances in the hope that they would kill weevils in grain, and all without real success. The substances include carbon bisulphide, wood-ash, dusts of fine earths (but not diatomaceous earth), tobacco, chillies, etc. When walking round some rather out-of-the-way farms I casually asked a Somali farmer what he did about weevils, and he told me that he used petrol. I accordingly did a few rough experiments with the following results.

Two petrol tins of sorghum each containing four gallons of grain were obtained. The grain was severely infested with weevils. To one tin was added 10 c.c. of petrol and the other was left as a control. Both tins were covered with a tarpaulin. The petrol was not mixed with the grain but merely poured on the top of it. After 48 hours the tins were opened and the control was found to be heavily infested, on the other hand the treated tin contained only two live weevils, and several thousand dead ones. Two hundred of these were placed in a warm and airy place for 12 hours and none of them revived. The grain was then tested for palatability and a sample was cooked; it was not tainted by petrol. A faggot was then inserted into the tin to see if an explosion could be obtained; the result was negative.

It may be that, particularly for native use, petrol may be of value in the control of weevils, but I would suggest that this rough trial be confirmed."

Capt. Peck's letter was referred to local Entomologists for comment and the following interesting results are reported by Mr. W. V. Harris of the Tanganyika Department of Agriculture:—

"I have carried out the following trials with petrol as a fumigant:—

(*a*) To a seed bin, 2 cu. ft. capacity, filled with infested maize, 1 fluid oz. petrol was added (equivalent to Peck's 10 c.c. per 4-gallon tin). The lid did not fit very well, so one thickness of brown paper was tied over. After 48 hours the bin was opened. Practically all the weevils were found alive, congregated at the bottom of the bin.

(*b*) To an airtight box of 4 cu. ft. capacity, filled with infested maize, 4 fl. oz. petrol was added. After 48 hours, two live *Calandra* were found, several hundred were dead and did not recover after airing for 24 hours. Numerous *Tribolium* (flour beetles) were all dead.

(*c*) Similar box and treatment using beans (*Phaseolus vulgaris*) heavily infested with *Bruchus* (so-called "bean weevils"), to which mill sweepings containing a large variety of stored-produce insects had been added as well. Result—all *Bruchus* and other insects dead except the larvæ of the large black *Cadelle* beetle.

Petrol thus appears to have definite possibilities as a fumigant. Germination tests have shown no ill effect with maize or beans. Owing to its lightness, petrol vapour requires a much tighter container than does carbon bisulphide, and that is going to be a practical difficulty. Peck's suggestion of ½ fl. oz. per cubic foot seems low for our conditions, though double this amount, as used in (*b*) and (*c*) above, may be unnecessarily high. One pint of petrol to 25 cubic feet would be a fair quantity for a well-sealed container. This is a lot compared with the standard dose of 0.15 pint of carbon bisulphide for the same volume of container, but now that carbon bisulphide is unobtainable this objection loses its force."

QUINUA (CHENOPODIUM QUINOA)

By L. A. Elmer, Asst. Agricultural Officer, Kenya.

A nutritious food crop from the Andes named *Quinua,* Inca wheat, or Little Rice, has been acclimatized and grown successfully on a small scale in Kenya. It is claimed to be the food crop which thrives at greater altitudes than any other, that it can withstand frost, and will yield a return under conditions so dry as to prohibit most crops from growing. The plant is *Chenopodium quinoa.* In these notes the Peruvian custom of referring both to the crop and the grain as *quinua* is used.

In a pamphlet issued by the Department of Agriculture, Peru ("*Quinua*: *Arrocillo o Trigo Inca,*" Divulgacion Botanica, Agricola y de Utilizacion Industrial y Culimaria; Abril XII de MCXXXIX, Cuzco, Peru) it is stated that *quinua* was a sacred Inca food. It is recorded as being cultivated by the Indians originally in the high country of Peru and Bolivia, particularly around Lake Titicaca.

The plant attains a height of from four to five feet and has a stout branched stem, large triangular-ovate leaves borne on long stalks, and densely clustered small green flowers produced in axillary and terminal panicles. The seeds are small, round and flattened, and measure about 1.4 mm. in diameter. About 520 seeds weigh 1 gram. The seed heads are heavy and are liable to be broken down by storms.

There are many varieties; different colours varying from white and cream to red and black are mentioned, the white or cream being the more popular. At an experimental grain station in Peru (in Kcaira), thirteen out of over one hundred varieties are under investigation.

The plant grows at high elevations in Peru up to 12,000 feet, taking from five to seven months to mature. It is resistant to frost and drought, and is very tolerant as to soil. It prefers silicacious soils rich in lime, potash and manganese. In Peru, dressings of wood ashes, or a mixture of wood ashes and lime at the rate of about half a ton to the acre, followed by guano when the plants are small, are recommended if suitable artificials are not available.

When mature, the plants turn yellow, and the custom of the Indians is to cut and dry them in the sun for a few days, after which they thresh out the seed with sticks and winnow it in the wind. A wheat-threshing outfit has been adapted to deal with it in one part of Peru.

Few pests attack the crop, birds being the most serious. Ordinary yields in Peru are from 450 lb. to 900 lb. an acre, but under good conditions over 2,650 lb. per acre are reaped.

Uncooked *quinua* is bitter to taste, but this flavour is removed by soaking in water. It is stated elsewhere that foreigners do not like *quinua* porridge, or the infusion of the toasted grain drunk as a beverage by people in Lima. The pamphlet makes no mention of this bitter taste, and it would seem that the Peruvians do not notice it. I have eaten porridge made of soaked and well-cooked *quinua* and found it palatable. It tastes something like porridge made from millet or kibbled wheat. The doughnut recipe is not a great success as the dough tends to crack up when cooked. Well-baked thin biscuits made of the doughnut mixture with double the quantity of wheat flour mentioned are good and have a distinct and pleasing taste.

Several analyses showing the food value are given in the pamphlet, and the following have been copied; the wide variation in the figures for fat and carbohydrate in the tables is probably due to different strains of *quinua* being examined:—

TABLE I

ANALYSES OF SEED

	U.S.A. Department of Agriculture	Peruvian Department of Agriculture
	Per cent	*Per cent*
Total moisture..	8·83	8·87
Ash	3·43	2·98
Fat	7·68	2·50
Protein	15·60	14·80
Carbohydrate ..	62·35	67·57
Cellulose.. ..	2·60	3·80

TABLE II

THE FOLLOWING IS A COMPARISON WITH OTHER GRAINS

Chemical Composition	*Quinua*	Wheat	Maize	Rice
	Per cent	*Per cent*	*Per cent*	*Per cent*
Nitrogenous material	16·5	11·0	9·5	6·5
Fats	4·4	1·55	4·7	0·5
Carbohydrate ..	51·0	71·0	70·0	78·0
Mineral	3·37	1·8	1·27	0·49

Chemical Composition	Oats	Rye	Barley
	Per cent	*Per cent*	*Per cent*
Nitrogenous material ..	10·5	8·0	10·0
Fats	4·0	1·18	1·5
Carbohydrate	60·0	72·5	70·5
Mineral	3·5	1·5	1·5

TABLE III

A comparison of White Wheaten Flour and Quinua Flour

	White flour	Quinua flour
	Per cent	Per cent
Carbohydrate ..	60	56
Protein	10	22
Fats	2	4

In milling about 93.20 per cent of flour and 6.80 per cent of bran are obtained from *quinua*.

It is claimed that the flour can be mixed with or substituted for wheaten flour for ordinary culinary purposes.

The following recipes are taken from the pamphlet:—

Quinua Cake.—Mix 3 lb. of *quinua* flour (or 2 lb. *quinua* and 1 lb. wheat flour) with 1 lb. sugar and 1 lb. butter. Beat the yolks and whites of 12 eggs separately. The whites should be frothed. Then beat the eggs in with the above mixture. Add a mixture of 2 teaspoons of bicarbonate of soda and 1 teaspoon of cream of tartar and 1 teaspoon of orange flower water. Mix thoroughly, knead and bake in a moderate oven.

Quinua Croquettes.—Boil 1 lb. of whole *quinua* until the grains have burst. Add salt to taste when boiling. Strain off the water and when cold add two beaten eggs and one or two tablespoons of grated cheese and two of flour (*quinua* or wheat). Make up into croquettes and fry in hot fat till a golden brown colour is obtained. Serve hot.

Chicken and Quinua Pie.—Boil 1 lb. whole *quinua* in water, add salt to taste when boiling. When soft strain off the water and allow to cool. Beat up 5 eggs and add with 5 tablespoons of wheaten or *quinua* flour, half cup of milk, 3 or 4 tablespoons grated cheese and pepper to taste. Slice and fry about 1 lb. of chicken in lard and mince this or cut up fine. Into a pie-dish place alternate layers of the *quinua* paste and minced chicken and bake lightly.

Quinua Doughnuts.—Cook 1 lb. whole *quinua* in water or milk, adding a few drops of essence of vanilla or cinnamon. When cold add 3 well-beaten eggs, 3 tablespoons flour, sugar to taste and a teaspoonful of baking powder. Form into doughnuts and fry in very hot lard.

Quinua Custard or Pudding.—Boil 1 quart of milk flavoured with vanilla or cinnamon and sugar. Stir in gently 4 tablespoons of *quinua* and continue stirring until it thickens. Pour into a dish to set. Serve cold. (The Peruvians grate burnt sugar over it before serving.)

Quinua Sweetmeats.—Sweets are made of this grain cooked and mixed with honey. Small balls are formed, rolled in maize flour and baked lightly.

In Kenya *quinua* was first planted in 1935. A small sample of seed of a cream colour was received from the Royal Botanic Gardens, Kew, and tried at Kitale and Kapenguria, Suk Reserve. It failed at Kitale (6,000 ft.), but at Kapenguria (7,000 ft.) a remarkable return of 5 lb. from 100 seeds was obtained by Mr. G. H. Chaundy, Principal of the Government School. This return is about eleven thousand-fold. Mr. Chaundy states that *quinua* does best in the high country of West Suk, and should be planted towards the end of the rainy season there (July or August) so as to enable the crop to ripen during the dry weather of November and December. The Suk have found that, unless the grain is soaked overnight before boiling the next day, it is inclined to be bitter. They usually cook it for an hour and add salt.

In 1939 seed from Kapenguria was planted in the native smallholding at the Scott Agricultural Laboratories, where it was the only annual to give a return during the drought of that year. Beans and peas growing in the same field perished from drought. The actual rainfall on the *quinua* was about 11 inches, but the distribution was bad and spells of great heat were common.

It is noteworthy that these laboratories stand at 5,700 feet, and that after four years at Kapenguria (7,000 feet) the seed which had previously failed at 6,000 feet was able to grow at a lower level. The growth, however, was never very good at the laboratories, the plants averaging about 10 inches in height with correspondingly light yields.

Trials in the Kiambu Native Reserve near Uplands, at about 8,000 feet, have been successful. The seed is planted thinly in shallow drills, 18 in. apart, and at 3 in. high the plants are thinned out to 6 or 7 in. apart. Growth reaches a height of 2 feet, and the crop is ripe about five months after planting.

The highest yield so far as Uplands has been at the rate of 750 lb. per acre. The plot there is part of a native shamba, rather closed in by trees, and with a poorish light soil.

It appears that the somewhat drier climate and better soil at Kapenguria are more favourable than at Uplands. Mr. Chaundy states that *quinua* does not require very rich soil, as it is liable to grow too tall (5 ft. to 6 ft.), and as a result gets blown over during a gale.

Under the damper conditions around Uplands the samples of seed produced have never been so bright and light coloured as those grown at Kapenguria. The average rainfall at the latter place, covering the months suitable for growing *quinua,* is as follows: July, 7.38 in.; August, 6.73 in.; September, 3.31 in.; October, 2.39 in.; November, 1.86 in.; December, 0.82 in.

From a study of *quinua* under Kenya conditions, I have come to the following conclusions:—

It is an adaptable plant and likely to flourish anywhere in East Africa at altitudes of 6,000 feet and over, under conditions which allow it from 15 in. to 25 in. of rain during its growing period and a dry season for harvesting.

It can be planted in shallow drills from 18 in. to 3 ft. apart, and be thinned out to spacings of from 6 in. to 12 in. in the row. The better the soil the further apart the plants should be to encourage sturdy growth. If the land is not infested with weeds, the seed can be broadcast at the rate of 20 lb. to 30 lb. to the acre and harrowed in. Germination usually takes from 7 to 10 days.

Cultivation and weeding of the growing crop is necessary until the plants are sufficiently big to smother weed growth.

Depending on the climate, harvesting may begin in from 4½ to 6 months from planting, the higher the altitude the slower being the crop.

When the plants turn yellow and before the seed begins to shed, the crop should be cut and dried thoroughly. In practice one waits until a plant here and there sheds a few seeds and then cuts the whole plot.

The seed can be rubbed out by hand or threshed with sticks on a tarpaulin. Care should be taken to prevent damage to the seed by rain or damp, as it discolours easily.

In addition to its potential value as a food crop for the higher parts of East Africa, *quinua* is worthy of the attention of poultry and pig keepers, as the high protein content makes it a valuable food, and it is easy to grow.

Remarkable increases in the fattening of stock in Peru were found when as little as ten per cent of the concentrates consisted of *quinua* meal as compared with equivalent weights of—

(*a*) barley meal alone;

(*b*) a mixture of three parts barley meal and one of wheat meal;

(*c*) barley meal with ten per cent of horse-bean meal.

Note.—I am indebted to Mr. M. Halcrow, Department of Agriculture, St. Helena, who commenced investigations on *quinua* in Kenya before he was seconded in 1939, for some details included in the above.

Since the above was written, Mr. Halcrow, Agricultural Officer, St. Helena, writes: "Quinoa will become an important crop here in time to come, I feel sure, because it is the only approach to a small grains crop that will withstand the ravages of canaries, Java sparrows, cardinals, etc. I have already obtained here yields of 600 lb. of seed per acre. Actually one of the best uses of the plant is as green manure crop for small gardens. I have demonstrated 100 per cent increase in yield of potatoes by this means."

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THE ENGENDERING OF KNOWLEDGE

"Thoughts cannot work upon nothing, no more than hands; he that will build an house, must provide Materials. And on the contrary, the Materials will never become an house, unless by certain Rules he joyn them all together. So it is not simply the knowledge of many things, but a multifarious copulation of them in the mind, that becomes prolifick of further knowledge."

Nehemiah Grew (1641-1712), quoted in *Nature*, Vol. 147, p. 632, 1941.

SOIL EROSION IN ARIZONA

The rugged individuals of one generation have bequeathed to their sons little more than an opportunity to be ruggeder still. The desert hills have been swept clean of feed for cattle; forests containing easily marketable timber have been massacred without quarter . . .

J. B. Priestley.

THE GROWTH-RATES OF LOCAL AND CROSS-BRED SHEEP

By M. H. French, M.A., Ph.D., Dip. Agric. (Cantab)
(Mpwapwa: Tanganyika Territory)

Adapted from an article in Part II, *Annual Report, Veterinary Department, 1939, the publication of which has been held up owing to war economies.*

It is well known that the indigenous sheep of this territory are small, slow-growing animals when compared with improved British breeds, but there are no recorded data either in support of this or by which the growth-rates of local flocks or cross-bred sheep can be judged.

In recent years attempts have been made at Mpwapwa to improve the mutton capabilities of local sheep and, in connexion with this work, data were collected on growth rates. Mpwapwa is not suited to sheep farming and it is possible that higher rates of growth may be found in more favourable localities, but the Mpwapwa figures are of value in showing the rates of development under dry, poor conditions. Further, the indigenous and cross-bred sheep were managed in the same way and so a direct comparison can be made of their growth rates. The testing of cross-bred types under hard conditions is in many ways an advantage because any improvements obtained under these conditions would probably be even more marked in a more favourable environment.

TABLE I
GROWTH RATES OF SHEEP IN 1938
Weights in lb. and oz.

Age	Three-quarter Grade Black-headed Persian		Pure Masai		Pure Ugogo	
	Lb.	*Oz.*	*Lb.*	*Oz.*	*Lb.*	*Oz.*
Birth ..	5	13	6	10	4	11
1 month	12	13	13	15	10	1
2 months	18	11	20	9	13	15
3 ,,	21	15	26	3	17	15
4 ,,	24	15	32	4	22	6
5 ,,	27	4	34	6	24	14
6 ,,	32	5	38	6	26	5
7 ,,	35	5	40	8	32	8
8 ,,	37	5	45	14	33	15
9 ,,	39	8	50	11	36	10
10 ,,	41	6	55	8	38	7
11 ,,	43	5	57	11	39	3
12 ,,	46	4	59	7	42	2
14 ,,	51	6	68	8	48	10
16 ,,	54	2	73	11	53	2
18 ,,	55	9	76	5	54	11

Table I gives the growth rates obtained in the 1938 lambing season for Masai, Ugogo and three-quarter grade black-headed Persian sheep. The latter were obtained by crossing imported Persian rams with Ugogo ewes, and mating the half-bred ewes to pure Persian rams to give three-quarter grade sheep. The lambs recorded in this paper are the progeny of three-quarter grade rams on three-quarter grade ewes.

It is seen from these figures that the short-tailed Masai sheep made greater liveweight increases than the long-tailed Ugogo type. The three-quarter grade Persian sheep were intermediate between these, with values nearer to those of the Masai sheep up till six months old. Their growth rates then fell off and at 18 months old were about the same as those for Ugogo sheep.

Considerable differences exist in conformation, as was shown in the Annual Report, Veterinary Department, 1938, Part II, page 62. The Persian crosses had better sprung ribs, well-filled tails and a good development of subcutaneous fat at a much earlier age than the Tanganyika types and consequently looked more finished and were ready for killing at an earlier age. They can give small carcasses at an early age, when the local types would be insufficiently developed, though, in the case of the Masai sheep, they will weigh more. The Masai sheep develop big frames before any large deposition of fat occurs and must therefore be killed at heavier weights than the Persian crosses. The Ugogo type can be killed at weights intermediate between those of the Persian and Masai sheep, but to reach the correct degree of finish must be killed at a slightly older age than the Masai type.

In the 1939 lambing season the growth rates in Table II were obtained. For each cross-bred the first name given indicates the breed of the dams.

The weights for the pure Ugogo sheep compare closely with the 1938 figures, whilst the Masai sheep were not quite so good. Even so, the Masai gained in liveweight and height faster than the Ugogo sheep. The Ugogo × Masai cross was intermediate between the two pure types, and it was unfortunate that only one lamb of the Masai × Ugogo cross was obtained and so these figures cannot be included. The crosses from grade black-headed Persian ewes with Ugogo and Masai rams grew at a similar rate to the Ugogo × Masai cross and not so fast as pure Masai sheep.

The cross-bred lambs from black Welsh Mountain rams on Ugogo, Masai and grade Persian ewes were heavier at birth than the other cross-bred lambs and also slightly heavier than pure Masai lambs. This superiority in weight was, however, not maintained and at three months old they were

TABLE II

GROWTH RATES OF SHEEP IN 1939 (Weights in lb. and oz.)

Age	Pure Ugogo	Pure Masai	Ugogo × Masai	Black-headed Persian × Ugogo	Black-headed Persian × Masai	Black-headed Persian × Black Welsh Mountain	Masai × Black Welsh Mountain	Ugogo × Black Welsh Mountain
Birth ..	4 13	6 11	5 0	5 6	5 1	7 1	7 2	6 14
1 month	9 9	14 8	10 9	11 6	9 14	14 11	15 2	13 6
2 months	13 11	20 1	15 14	14 3	13 15	19 5	19 8	14 0
3 ,,	15 15	23 10	21 14	15 11	21 3	22 13	21 8	—
4 ,,	22 11	26 9	24 15	19 11	24 4	25 5	22 8	—
5 ,,	24 10	31 2	27 9	23 3	27 7	27 5	27 4	—
6 ,,	27 5	34 5	31 0	26 11	28 11	31 7	31 4	—
7 ,,	31 13	37 8	32 8	30 8	30 7	35 14	36 0	—
8 ,,	33 6	42 10	33 10	34 11	32 6	38 0	38 5	—
9 ,,	—	—	36 1	—	36 3	—	—	—
10 ,,	—	—	39 0	—	38 15	—	—	—

lighter than pure Masai lambs, and during the 1939 season they never regained their initial advantage. I consider one of the reasons for this slowing up of the growth rate was because the ewes (chiefly three-quarter grade Persians) had insufficient milk for their half-grade Welsh offspring. In three cases lambs were put on to bottle feeding before they were three weeks old and the average results obtained were as follows:—Birth weight 7.5 lb., at five months 31.56 lb., and at eight months 46.69 lb. These three lambs made liveweight gains greater than that of any other cross and at eight months were heavier than the pure Masai lambs. In the other cases, where half-grade Welsh lambs were hand fed, they had lost weight for three weeks before being put on to bottle feeding and did not catch up again.

The appearance of the half-grade Welsh lambs, on the whole, was far from good. They appeared leggy and unhappy, and trailed wearily after their dams. Their constitution was below that of local types or their crosses, so that under Mpwapwa conditions grading up with Welsh rams cannot be considered satisfactory and their mortality rate was high.

For the 1939 season, lambs with no Welsh blood in their ancestry showed a mortality rate in their first six months of 26.5 per cent, whereas the progency of Welsh mountain rams showed 45.8 per cent mortality in the same period. These figures alone indicate that sheep of all breeds, and particularly the Welsh crosses, are not doing well under the conditions near the laboratory, and there is, therefore, a strong argument in favour of studying breeding problems under more suitable conditions. Although the Welsh crosses have shown up the worst here, I think they should not be condemned outright on the Mpwapwa results alone.

The Welsh Mountain half-grades are very similar in appearance whether obtained from a brown Masai, a black-headed Persian grade or a multi-coloured Ugogo ewe. The black colour of the sire stamps itself on the offspring and many are completely black, whilst others have only a few small white spots. The tail is long and shows a tendency to thicken and accumulate fat only in the portion nearest the rump. The lower part is not fattened at all. A short, coarse, dense wool covers the body, but the legs are covered with hair. In my opinion too much wool is carried, and it will probably be found that the half-bred ewes will need crossing back to Masai rams to get quarter-grade Welsh progeny which will carry a less woolly coat. These quarter-grade lambs will probably be more in harmony with Tanganyika conditions and have a more robust and healthy appearance. At the time of writing, however, no quarter-bred Welsh progeny are available, and the few half-grades which have survived at Mpwapwa are poor specimens. For hard conditions the introduction of Welsh blood has resulted in half-grade sheep which are out of harmony with their surroundings and which are inferior to local types or crosses. The growth rates are poor, the mortality rates are high and the survivors have poor constitutions and no better mutton potentialities than the Masai sheep. In fact, from external appearance, the Masai look the better animals.

The introduction of black-headed Persian blood into local sheep allowed carcasses to be finished at an earlier age, although the carcass weights would be smaller than from similarly finished local carcasses. There is little to choose between the qualities of the local types; the Ugogo gives a slightly smaller (though older) carcass than the Masai, but the latter give the better distribution of fat. Crosses between Ugogo and Masai give carcasses intermediate between the two local types.

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AN IMPROVED IMPLEMENT FOR USE IN COMPOST-MAKING

By J. D. Scott, Officer in Charge, Estcourt and Tabamhlope Research Stations, Division of Soil and Veld Conservation

In the making of compost at the Estcourt and Tabamhlope Stations, all dry stock are fed in kraals during the winter to afford them maximum protection against cold. A fresh layer of bedding is added to the kraals each week or whenever required until, by the end of the winter, a mixture of grass, dung and urine to a depth of a couple of feet is obtained. This is not touched during the winter, as temperatures are too low and there is not enough moisture for much bacterial action.

At the end of the winter the cattle return to the veld and, after the bedding in the kraals has been wetted thoroughly by rain, it is built up into heaps about 4 ft. 6 in. high, varying in width from 12 to 18 ft. and in length from 25 to 60 ft. The removal of the material from the floor of the kraal has always been an expensive process. Turning by means of a plough has resulted in continual packing in front of the plough, and a dam scoop has always jumped. As a result, the material has had to be removed by hand labour with forks and wheelbarrows, which is slow and expensive.

This season an improvement to a dam scoop was tried, with excellent results. Four iron bands, 2 in. wide and ½ in. thick, sharpened to a point, were riveted under a dam scoop so that the two middle ones projected about 11¾ in. and the two outer ones 10 in. in front of the scoop, being just clear of the inside of the drawbar. In addition to the rivets, the front edge of the scoop was welded to the bars, so that there was no chance of material working between the bars and the scoop.

These sharpened bars penetrated the mixture on the kraal floor easily, and it was possible for two boys to remove all the material, with two oxen drawing the dam scoop. As the passage of the oxen over a heap would have consolidated it too much, the compost material was dumped outside the kraal, where two other boys packed it into the heaps.

This improved implement has cut down the cost of compost-making at Estcourt enormously. Two boys with two big oxen in this scoop took the compost material out of the kraal at the rate of just under 19 tons per day (1 cu. yd. at 70 per cent moisture weighs approximately half a ton), and with two boys packing it into heaps, it was possible to build a stack 25 ft. by 18 ft. by 4½ ft. high in two days.

The cost of effecting these improvements to the scoop (at the present price of iron) is only a matter of about £2 10s., and this amount is easily saved in labour within the first few days. The bands riveted underneath act as shoes, taking all the wear and thus adding considerably to the life of the scoop.

Extracted from *Farming in South Africa*, Vol. XVI, No. 182, page 187, May, 1941.

REVIEWS

WHITE SETTLERS IN THE TROPICS by A. Grenfell Price; American Geographical Society, New York; 1939.

In attempting a much overdue review of this important and interesting book, it is as well to point out at the start that the work, like several others on the same subject which have appeared during the last decade, is—admittedly—suffering from our as yet profound ignorance of many interrelated aspects and problems, resulting in, as often as not, diametrically opposed schools of thought with their conflicting and, thereby, confusing theories; a state of affairs made worse by the tendency of many workers in this complex field to let themselves be ruled by wishful rather than clear thinking! On the other hand, Dr. Grenfell Price, an Australian educated at Adelaide and Oxford, and entirely free, it appears, from this anti-scientific vice of wishful thinking, deserves our fullest gratitude for this comprehensive and cautious, valuable and useful synthesis which compresses into a readable and handy form a vast amount of material scattered through generally not easily accessible publications; and, above all, never tires of pleading for more scientific research in order to remove the existing difficulties from a branch of knowledge destined to be of the greatest importance for the future development, and for the geographically "correct" distribution over the surface of the earth, of *Homo sapiens*. Indeed, so convinced is the author that political and economic policies will never succeed unless they are based on facts evolved by science, that his highly significant concluding sentence (p. 238), short, simple and straightforward, reads, "In the hands of scientific workers lies the solution".

In his "definitions", Price limits the tropics to the areas confined within the mean isotherm of 70 degrees Fahrenheit, and distinguishes between mere "sojourners" and proper "settlers", i.e. "people and their descendants who follow all the usual routine of life, including manual labour, maintain their standards of health, energy, civilization and culture, and raise families that do not exhibit mental or physical degeneracy" (pp. 3-4), a definition identical with that adapted by myself as early as 1937 in my writings on white settlement.

Regarding methods of attack, the author distinguishes the historical, statistical and laboratory methods, and comes to the conclusion that it is doubtful if the truth can be discovered by historical research alone; that with a still great want of data, and with such data as exist having been collected under many far from uniform systems, the statistical method shows several weaknesses; and that, although the laboratory is the most hopeful line of attack, "it cannot touch a vast mass of environmental, racial, economic and political factors, nor can it as yet explain important psychological and moral changes" (pp. 11-12).

The many attempts to establish white communities in the tropics he divides into former "pre-scientific" and the present "scientific" invasions; and also separates the invaders into "Mediterranean" and "North European" groups, paying, with few exceptions, dominant attention to the problems of the latter.

Chapters II and III are a short but good summary of the pre-scientific failures, shown to have been due to ill-treatment of white labour, wars and buccaneering, soil exhaustion and other economic and administrative factors, faulty diet, clothing and housing, and chiefly to the white man's inability to resist successfully the competition of races of lower economic and social status; whereas the question of how far collapse was due to the tropical climate *per se* remains a "fundamental and most mysterious problem" (p. 29). In Chapter IV, dealing with the scientific era, the results of the gradual improvement of transport and of the part played by medical and sanitary science are discussed with a sound and emphatic warning against over-optimism based on medical achievement, and an equally sound and full realization of the obstacle against white penetration and security offered by indigenous or imported coloured peoples.

Part II, comprising 130 pages or a little more than half the main text, contains regional studies of some of the more important tropical white settlements, "in order to ascertain why, in a general welter of failure, these white communities survived for considerable periods and, in some cases, met with encouraging success" (p. 171). The author, however, does not claim that this detailed study of some tropical settlements can solve our problems, although he expresses the hope that "it may bring the underlying factors into clearer light" (p. 41). The examples chosen lie in the "Trade-Wind Margins" (Florida and Queensland); in the "Trade-Wind Islands" of the West Indies; in "Arid and Wet-Dry Australia"; in the "Tropical Plateaus" of Central and South America and Africa; and in Panama. It will thus be seen

that, with the exception of the last locality, the definitely humid and low-lying tropics, such as the Congo and Amazonas Basins, West Africa, parts of India, Burma and Malaya, etc., are excluded from the discussion as "many eminent authorities doubt if the white will ever occupy them" although, according to some writers, they "offer the highest potentialities for the production of raw materials and food" (p. 8), the last a statement which I cannot share (C.G.).

Even Florida, distinctly marginal to the tropics and therefore but little suited to shed light on our East African problems, is said to form "a battleground for scientific optimists and pessimists" (p. 47), and is considered "a young and uncertain experiment" (p. 45).

Eastern and North-Eastern Queensland, the showpiece about which so much has been and is being written, is likewise very marginal, especially in its more densely occupied southern parts, and is, furthermore, "an area with exceptional advantages" (p. 57). In his lengthy and detailed analysis, based on personal knowledge of this key area, the author emphasizes the beneficial factors of protection and embargoes, of an adequate living standard supported by the whole Australian nation, the absence of a large and competing native population, the recentness of white penetration, and the dangers (to British settlers) of Italian competition, but even with so much in favour of the whites he reaches the conclusion that "although the outlook is favourable at present, the future of the British whites in Queensland must remain for some generations a matter of doubt" (p. 73).

The West Indian Islands all lie in the favourable trade-wind belt and strongly reflect this control. The populations dealt with are mostly of Mediterranean descent, and the terms "whites" and "near-whites" must, in my opinion, be taken *cum grano salis* throughout Central and South America. Of the few exceptional examples of survival of northern whites (St. Martin, Saba, and a few isolated British, German and French remnants, including the "Red Legs" of Barbados) none seem to be very hopeful, and in any case all are far too small to permit conclusions to be drawn from their history and present state, for the fate of larger units in other parts of the world. It is, however, significant that these "whites do best in, and deliberately seek, regions of steady air movements, such as the trades" (p. 102).

Arid tropical Australia is considered "totally unsuited to the intensive settlement of any human race" (p. 104). The attempted occupation of the wet-dry regions of winter drought in Australia, which most closely resemble our East and Central African savanna lands (except that they carry a much less dense native population) teaches, in the author's words, which I fully endorse, "many highly important lessons and, not least, the folly of attempting to occupy an unknown country without previously making a scientific survey" (p. 104). The "White Australia" policy entered this area, where soils and climate are against close settlement, "to play its tragic comedy in raiments of borrowed gold" (p. 112), and the conclusion is that "in these circumstances Australians would, in all probability, be wise to cease boasting about the 'vast undeveloped potentialities' of tropical Australia. They should place before the world the picture of these regions as painted by scientific knowledge. They should treat them as pastoral and mining areas and avoid further misdirected and expensive experiments" (p. 121). To all of which I can only add, "*Tout comme chez nous* in Tanganyika!"

Of the tropical plateaus, Costa Rica and parts of South America are given considerable scope. Though interesting in a general way, especially as regards the handicapping element of isolation, they are not helping towards a better understanding of East African conditions, as again the "whites" and "near-whites" are of Mediterranean descent. Statistics about race are particularly untrustworthy (p. 132), and intermixture is proceeding apace, particularly in the "vast melting-pot" of Brazil, where the evolution of a mixed Indian-negro-white race has recently become the established policy of government.

The chapter on the East African Plateaus is disappointingly short (six pages only!), and unfortunately does not discuss the physiological and psychological effects of tropical high altitudes (although A. Walter's paper on "Climate and White Settlement in E.A. Highlands" is called "very frank and sane" in a footnote). Admitting that "most authorities express cautious views on the present evidence" (p. 137), the conclusions reached by Price are that "the Rhodesias and Nyasaland form three archipelagos of settlement in a sea of bush and scrub, with smaller island clusters in Angola, Kenya and Tanganyika. In these tropical highlands the white man is establishing a culture that is essentially dependent on the exploitation of native labour, and the white man must always be in a position of master or foreman" (p. 137); that "almost every authority states unequivocally that the great economic and social problems

arising from inter-racial relations are the crux of the matter" (p. 140); that "biologically the future is a mark of interrogation. The British whites of East Africa may, perhaps, evolve into working communities and hold their own against the negro. It seems more likely, however, that the negro will undercut or absorb or drive out these whites as he has done in most parts of tropical America and the West Indies" (p. 142); and, finally, with regard to the "poor whites" problem, that "if the whites, who are numerous and firmly established in southern Africa, are facing grave difficulties and doubtful prospects, what are the hopes of 'the little white islands' of settlement on the tropical plateaus to the north?" (p. 145). No wonder, therefore, that the Dual Mandate policy seems to the author to lead to a fully justified fear of the settlers for their own future (p. 141).[1]

Compared with this Cinderella treatment of a (to us at least) very important part of the inner tropics, the small enclave of the American Panama Zone receives twenty-two pages! As a highly artificial region, not likely to be reproduced elsewhere, it has no comparative value. In fact, "it is an economic freak, and the white colony enjoys a high living standard for the tropics and a diet of a kind only available on one of the greatest highways of the world" (p. 221). But it is interesting to note that, even where no economic restrictions exist, "health conditions are still unsatisfactory except in certain small, highly sanitated areas . . . and most people require vacations in the cool-temperate zone" (p. 167).

Part III is an analysis of the chief known factors governing white settlement, i.e. the qualities of the immigrants, the environmental phenomena, and the external influences acting from the temperate zones, such as political pressure through political sovereignty, economic policies, markets, etc. As regards the first, the author feels bound to admit that "our knowledge of racial suitability or adaptability to tropical conditions remains vague" (p. 176-8), and this notwithstanding indications that southern Europeans, under certain safeguards, "can survive indefinitely over a large part of the tropics", and northern Europeans "can survive and breed for generations in the moderate tropics". The important problems of the mixture of ethnic groups is another field in which, for the present, we can only stress our scientific ignorance and press for further research.

In the chapter on environment, the paragraphs on tropical soils point out rightly that their nature is of profound importance to white settlement; most properly castigate "the old fallacy of the immense and widespread fertility of the tropics" (p. 233); and consider soil surveys "a vital necessity". As regards climate, it is pleasing to see that, not only in this chapter but throughout the book, the wind factor, so often overlooked by former writers, is given the full prominence it deserves; a factor which, incidentally, I hold largely responsible for the comparative advantages enjoyed by tropical, even equatorial, east coasts facing the trade-winds, like our own, if only town and individual dwelling sites are laid out in such a manner as to derive the maximum benefit from these winds. Closer investigation of geo- and astro-physical elements is advocated. Opinions regarding tropical highlands vary greatly and, generally, the author's conclusions are (1) that our present knowledge and methods for studying the interactions of climate and settlement "appear inadequate for sweeping generalizations, particularly as they must ignore local and micro-climates and non-climatic factors" (p. 192); and (2) that there is great need of further research.

Chapters XIV and XV deal with the bugbear and happy hunting ground for cranks of many varieties: acclimatization, a field, in the words of Professor Kenneth Black of Singapore, "so full of theory and with so few proved facts, that science plays a game of skittles" (p. 195). Price himself starts these chapters with the frank admission that in this basic problem of white settlement "unfortunately all types of evidence remain contradictory and complex" (p. 194), although "researches have been conducted in the field of physiology, beyond this lie vital problems of psychology and neurology still almost untouched" (p. 195). In the more strictly medical realm, the view, astounding perhaps to some of us steeped in the more optimistic outlook of leading British malariologists, is upheld that "malaria remains in a broad sense largely beyond control" (p. 205), "except in regions where very favourable economic conditions cover the high costs of sanitation" (p. 209). I am glad to see that the close relation between physiographical features and malaria—long since emphasized in my own writings—finds full endorsement (p. 209). The other great scourge of tropical mankind, hookworm, is considered "controllable among peoples of fair living standard and education" (p. 208), but taking the effects of medical efforts all round, all the author can say is "that science has made re-

[1] Incidentally, one wonders how the compilers of the T.T. Report of the Central Development Committee, 1940, or of similar documents, would react to sober statements like those quoted.

markable improvements in tropical health, but the fight is only just beginning, and as yet there is no certainty that scientific medicine will conquer, particularly in the hot, wet tropics" (p. 236). With regard to psychological and physiological disturbances the hope is expressed that "laboratory researches may yet dispel the clouds that overshadow the evidence of history, observation and statistics, and may give conclusive proof that the tropical settler faces physiological, neurological and psychological handicaps" (p. 216).

In the chapter on "Diet, Clothing and Exercise" we find the same note of uncertainty and warning against premature dogmatic conclusions, but one is glad that, unlike some other writers (e.g. J. Grober, *Der Weisse Mensch in Afrika und Sued Amerika,* 1939), Price does not advocate those exaggerated and severe restrictions which would, in any case, not help white settlement; for such settlement requires, obviously, ordinary human beings and not saints! The view is upheld that exercise, in the form of manual or other "labour", far from being detrimental to the white man or woman in the tropics, is more and more regarded as essential for overcoming many of the tropical drawbacks; a view which an old railway engineer and surveyor, who has spent more than twenty-five years in the tropics on strenuous outdoor "exercise" of this sort, with the greatest success for his own acclimatization and well-being, can fully and honestly endorse.

A chapter on "Administrative and Economic Problems" draws attention, among other things, to the dangers of "one-crop industries", but seems to me too short to do full justice to the outstanding fact that economic conditions are probably of paramount importance in deciding the fate of any scheme of settlement. Finally, there are six pages, concisely utilized for a remarkably lucid summing up of a book which is one of the excellently edited and handsomely produced special publications of the American Geographical Society. Three interesting appendices by Professor Robert G. Stone, of the Blue Hill Meteorological Observatory, provide very valuable information on a number of aspects of modern physiological research regarding acclimatization.

C. Gillman.

Cotton Breeding and Seed Supply, International Institute of Agriculture, Rome, 1938.

According to the introductory letter by the Secretary General, Dr. W. Bally is responsible for this interesting publication.

His analysis of breeding objectives is of particular interest, and he draws attention to the fact that the distribution of cotton varieties is in a constant state of flux owing to changing conditions and changing demands of the spinning industry. Consequently the work of the cotton-breeding stations never ceases.

In Part V there is a short account of the trends in cotton-breeding in some of the chief cotton-growing countries. It seems curious to omit Uganda and the Anglo-Egyptian Sudan from this list. These two territories between them produce nearly 83 per cent of the cotton grown in the British Empire, excluding India.

The author has repeated a statement originally made by S. C. Harland to the effect that modern Uplands are not adapted to tropical African conditions. This statement has given rise to a certain amount of confusion and resulted in correspondence between the Director of Agriculture and the Empire Cotton Growing Corporation (*vide* Vol. X of the *Empire Cotton Growing Review,* 1933, page 206). The older varieties of American Upland were introduced to various parts of East Africa twenty-five or so years ago with considerable success. It is true that so far we have not obtained any modern Upland varieties from America which have proved an unqualified success, but then we must remember that until the last year or so very few new American strains have been tried in Uganda. The American breeders have been concentrating on glabrous strains for some years past, whereas in East Africa, Nyasaland, Southern Rhodesia and South Africa the breeders have been selecting hairy strains to avoid damage by Jassid. Wilt diseases are prevalent in many parts of the cotton-growing areas of the United States, and there is little doubt that some of the recent wilt-resistant cottons will have considerable value in Uganda for crossing purposes.

On page 41, two axioms are quoted which should be ever in the mind of the practical cotton breeder: (i) no seed can be kept pure in bulk; (ii) a pure stock can be kept pure on a small scale for an unlimited time by the precautions which are practicable in a genetic laboratory. He also draws attention to the abandonment of rogueing of "off-type" plants by the Egyptian workers.

Some of the explanations and definitions contained in this memorandum display clear thinking. On page 34 the definitions of "variety", "strain" and "pure line" are well expressed. Section III on breeding methods is a clear

exposition, particularly sub-section (B) on selection, which sets out the relative merits of the "naked eye" and "mass of figures" methods. Section IV on propagation and conservation raises some interesting points. The "Hindi" seed question would be profitably employed in other countries, and is in fact under investigation in Uganda. A further interesting point is that in the United States private concerns encourage frequent seed changes for profit, whereas in many other countries free government distributions become infrequent and dilatory on account of their cost.

For the rest there is a good deal of encyclopædic work, but the disinterested position of the writer enables him to co-ordinate with remarkable lucidity and impartiality.

Soy Beans.

In an earlier volume of this Journal a book entitled *All about the Soy Bean,* by George Douglas Gray, was reviewed. Mention is now made of an article entitled "The Soybean—its politics, performances and possibilities," by W. Burns, C.I.E., D.Sc., I.A.S., Agricultural Commissioner with the Government of India, published in *Indian Farming,* Vol. II, No. 9, in September, 1941.

That article has one particular merit. It not only gives a useful account of the culture, performance and uses of the soybean, but it indicates to the prospective soybean planter the limitations of the crop, as a food and as an item for export. These are points less fully realized than the many merits of the crop, and they are therefore referred to briefly below.

As a food crop, the soybean would appear to have been overrated; the protein content, although as high as 40 per cent, cannot compare with the animal protein such as that in milk. Where pulses are already being grown, it would be difficult and probably unnecessary to introduce soybeans, but where no pulses are grown, suitable varieties of soybean might be introduced. Palatability is important, and methods of preparation would require to be evolved to suit local tastes.

For any purpose suitable varieties must be found, but the yellow varieties show most promise.

There are numerous uses for the soybean in commerce, and overproduction of the crop is unlikely for many years to come. Where export is in view, a consignment of at least a thousand tons is said to be required. Some prices are given, e.g. United Kingdom prices are said to have been roughly £8 a ton in 1938, and £15 a ton from July to December, 1940.

Although written primarily for the Indian planter, the article gives a very useful general account of the whole subject of soybeans, and East African planters contemplating growing the crop would be well advised to consult the original article.

G.B.W.

The Land Vertebrates of Pemba, Zanzibar, and Mafia: A Zoo-geographical Study, by R. E. Moreau and R. H. W. Pakenham (*Proc. Zool. Soc. Lond.*, Ser. A, Vol. 110, pp. 97-128. 1941).

This paper is a valuable contribution to our knowledge of the vertebrate fauna of the islands fringing the East African sea-coast, and of how and why this fauna differs from that of the adjacent mainland. The fauna is essentially (as might be expected) a much reduced version of that found on the mainland, with a very small Mascarene element (almost entirely confined to flying animals), and with a very low degree of endemicity; there are few endemic species and no endemic genera. Apart from any original inhabitants of the islands, flightless forms may probably have colonized them by the aid of rafts of debris brought down the mainland rivers by floods. Some other flightless forms have been introduced, deliberately or otherwise, by man.

To this reviewer, one of the most interesting points in the paper is its illustration of the way in which one branch of science can come to the aid of another when difficulties are encountered in the interpretation of facts; geologists are agreed that the isolation of Zanzibar and Mafia is not more ancient than the Pleistocene, and the zoological evidence fully confirms this opinion. But geologists disagree with regard to the antiquity of the isolation of Pemba; some regarding it as Pleistocene, while others claim that it is very much more ancient (Miocene). The faunistic evidence is wholly favourable to the Pleistocene date and almost conclusively against the Miocene. This point deserves emphasis because an unfortunate, but almost inevitable, result of the growing complexity of science is that the followers of each branch of science tend to work in a watertight compartment and fail to realize that apparently unrelated branches of knowledge may often throw light on their own problems.

A very welcome feature is the critical nature of the faunistic lists on which the discussion is based. Such lists are too often entirely uncritical, comprising a hotch-potch of genuine records, errors of identification, and records based on wrong labelling of the specimens. In the present lists many records are rejected, and the reasons for their rejection are given. So far as the reviewer is aware, these are the first comprehensive and critical lists of the vertebrate fauna of any part of East Africa. Such lists are of much more than purely scientific interest. To the farmer, for instance, it is important to know which species of birds frequenting his crops are (from his point of view) wholly destructive, which are helping him by destroying pests, and (still more), which more than balance the damage they do by the benefits they confer. Faunistic lists of this kind are an essential preliminary to the acquisition of such knowledge.

G.H.E.H.

THE CULTURE AND USE OF SORGHUMS FOR FORAGE, *Farmers' Bulletin* No. 1844, U.S. Dept. of Agriculture, March, 1940.

This bulletin contains information of considerable interest to a large section of farmers in East Africa. In recent years, marked progress has been made in the conservation of fodder for use in the drought periods of the year. The limitations of dependence on natural pasture have been recognized, and the fact is now widely accepted that provision for the dry-season shortage is almost as necessary as provision for the winter in British farming. As development towards high-yielding animals progresses, this fact is forced upon us.

In the moist regions selection of a suitable crop for storage presents little difficulty. Maize and Napier grass can be used, in addition to a range of crops grown in native agriculture. It is at the drier fringe of the mixed-farming region and in the ranching areas where difficulty arises as the result of erratic rainfall. It is for farmers in such areas that this description of sorghum culture in America holds particular interest. In order to produce a reserve supply of fodder, a drought-resistant crop is necessary, which is capable of rapid development in rainy seasons of short duration, and the sorghum group fulfils this requirement.

In the U.S.A. sorghums are grown mainly in the semi-arid plains, and many cultivated varieties have been developed. Despite the fact that most of these varieties originated in tropical Africa, their cultivation in a somewhat different environment, and development for the special requirements of American agriculture, appear to have made them less suited to our climate. Many of the American varieties have been tested in Kenya, with indifferent results, although a few have given definite promise. A range of sorghum types, some of which are probably the parent types of the American varieties in use to-day, has been cultivated by the natives of East Africa from ancient times.

This mixed population of native sorghums affords a very promising field in which to search for types suited to the requirements of our own developing stock industry, a field which is, so far, practically unexplored. Some indication of the possibilities in this direction is given by the article on Perennial Kavirondo Sorghum, published in the *East African Agricultural Journal* in April, 1941. In a recent report on a trial of this crop in South Africa it is stated to have flowered at five feet high in a period of eighty days from sowing.

In the bulletin a useful account of American experience of cultivation, harvesting and utilization of the sorghum crop is given, and some of the methods described should be of considerable assistance to farmers in this country. Special reference should perhaps be made to two points in this account: the rate of planting and the possibility of prussic acid poisoning. The weights of seed recommended for sowing are considerably less than those which have been used in experiments here, and it is probable that under our conditions lighter sowings would tend to greater drought resistance and larger forage yields. Experiment on this point is evidently necessary. In regard to the reputation of poisonous properties possessed by sorghum in America and other countries, this is known to be connected with climatic conditions as well as variety of plant, and, although in using the crop it would be advisable to take the precautions suggested in the bulletin, in the limited experience of sorghum-feeding in Kenya no case of poisoning has yet been recorded. The danger exists, in any case, only when the material is grazed or fed green, and does not affect stored fodder.

This bulletin is recommended to East African farmers in the hope that it will induce them to experiment with an African crop which appears to offer great possibilities under the exacting conditions of the drier areas, and which, hitherto, has received little attention.

D.C.E.

A NOTE ON STRIGA INVESTIGATIONS AT AMANI

By L. R. Doughty, B.Sc.(Agric.), N.D.A., Geneticist, Amani.

Two species of *Striga* are serious pests on grain crops in various parts of the tropics, and the necessity for adequate control measures is increasingly apparent. In South Africa, *Striga asiatica* (Linn.) O. Kuntze, commonly but incorrectly known as *S. lutea* Lour. ("Witchweed"), is the prevalent species. On European-owned estates trap cropping has proved the most efficacious method of control so far devised, but this has obvious disadvantages from the point of view of the native cultivator; resistance to, or tolerance of, the pest are of far more interest to him. In South Africa, Saunders [1] [4] has made a study of the life-history of *S. asiatica* and has bred resistant sorghums. In current agricultural literature from India and Burma there are frequent references to breeding sorghums resistant to attack by this species.

In the densely populated areas of Usukuma, south of Lake Victoria, *S. hermonthica* Benth. is a serious pest on sorghum, the most important food crop, and control is an urgent necessity. Uprooting the parasite before it flowers or seeds has proved a useful check, but to be fully effective the campaign must be prosecuted vigorously and continuously during the cropping season [2]. *S. asiatica* also occurs in this area, but is more widespread in south Usukuma and Unyamwezi, and is nowhere such a pest as *S. hermonthica* [2]. Sorghums resistant to *S. hermonthica* would be invaluable in this region, and trials have already been made with varieties that have shown resistance to *S. asiatica* in the hope that they would also show resistance to the other species. Four resistant varieties from South Africa were given a four years' trial at Ukiriguru on land infested with *S. hermonthica*, but they were not a success ([2] and Clarke, *in lit.*).

My connexion with the *Striga* problem began in 1939, when I visited the Lake and Western Provinces of Tanganyika to discuss with agricultural officers the possibility of finding resistant strains of sorghum. The main points of interest gleaned from this visit were:—

(1) The inhabitants of the areas most seriously infested have no knowledge of varieties of sorghum showing resistance.

(2) Intensity of attack varies in different seasons.

(3) Early-maturing varieties of sorghum do not suffer from attack to the same extent as long-term varieties. This appears to be due to the fact that they are mature by the time the weather is most favourable for the development of *Striga*.

(4) Field experiments at Ukiriguru indicate that less *S. hermonthica* appears on manured than on unmanured plots of sorghum.

(5) Maize is more tolerant of severe infestation than sorghum, but is not so suitable a crop for much of the heavier land.

After my return to Amani I planned a series of experiments to study the life-history of *S. hermonthica* and to compare it with that of *S. asiatica* as described by Saunders [1].

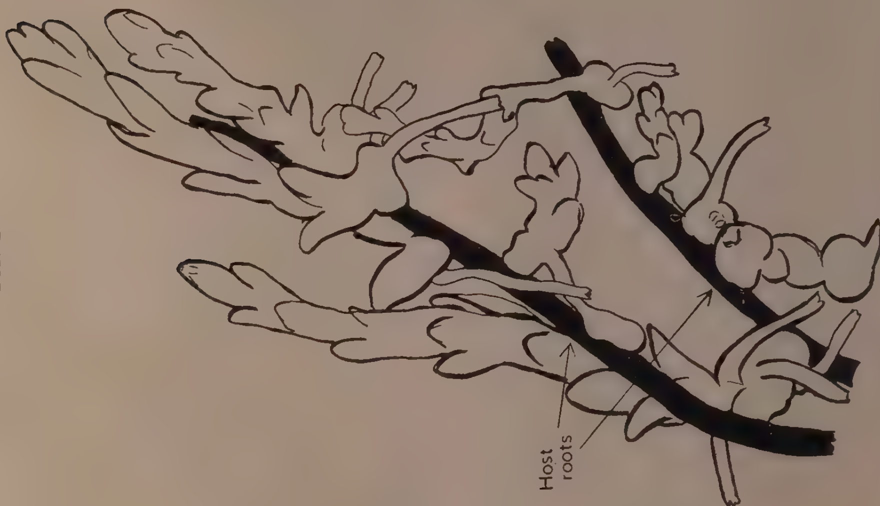
Tube Cultures

Observations.—Striga seed was sown on damped rectangles of filter paper inserted in glass tubes with the *Striga* seed next the glass; the tubes were filled with soil, in which the seed of the host was planted. The tubes were then encased in removable tubes made of paper having one surface matt black and facing inwards. Periodical inspection of the development of the host roots and the *Striga* seed was thus possible.

The first series of examinations covered the development of *S. hermonthica* on common sorghum (variety unknown), on maize (Hickory King), and on sorghum known to be resistant to *S. asiatica*, Kalipyaung from Burma [3], and three South African forms bred at Potchefstroom [4], Nos. 37 R 9, 37 R 29, and 37 R 37. The tubes were kept in an incubator at 30° C. until the host seeds had germinated. All hosts except the common sorghum and 37 R 37 germinated rapidly, and in five days roots were visible. *Striga* seeds began to germinate within seven days of the start of the experiment in close proximity to the visible host roots. At this early stage germinating *Striga* seeds were seen in the tubes containing resistant sorghums 37 R 9, 37 R 29 (see Fig. 1), Kalipyaung, and also maize.

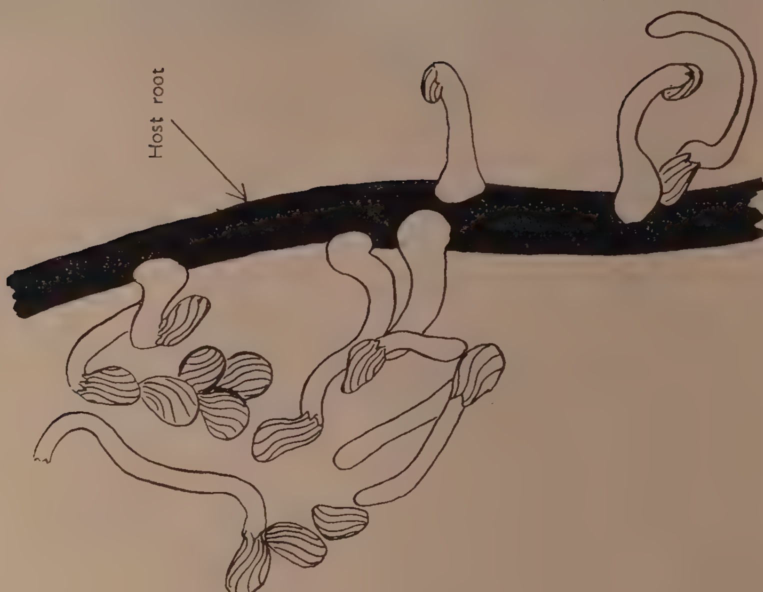
In Fig. 1 it is apparent that the roots of six of the germinating seeds have made contact with the host root and that five others show no tendency to grow in the direction of the host root. This lack of directive stimulus was noted in most tubes containing germinating *Striga* seeds. Saunders [2] noted this in his studies of *S. asiatica* when excess of water was present in the cultures.

FIG. 2



S. hermonthica on Sorghum, Kalipyaung

FIG. 1



S. hermonthica on Sorghum 37 R 29

More tubes were prepared using the same sorghum hosts and *S. asiatica*. The hosts in these tubes germinated in three days, but 37 R 29 and Kalipyaung still had no visible roots and no germinating *Striga* seeds when, after nine days, germinating *Striga* was observed in the other tubes.

As the *Striga* seed in both experiments was distributed thinly over the whole of the inner surface of the tubes it was impossible to make a count of the total number present. It was evident, however, that only a very small proportion of the seeds germinated, even of those in close proximity to the host roots, and many of those that did so failed to make contact with host roots and consequently died.

The first experiment with *S. hermonthica* concluded after one month, and the soil in the tubes was carefully washed away from the host roots. Few young *Striga* plants had developed except on maize. This host had a much more vigorous root system than any of the sorghums. Most of the latter had produced a rather restricted primary root system and a more prolific secondary one in the upper part of the tube above the general level of the *Striga* seed.

The tubes containing *S. asiatica* were treated in a similar manner. Only one young *Striga* plant was found, and this on 37 R 9.

For the above experiments Amani soil was used. Similar soil used in the bucket cultures described later had a pH about 4.5. It was though that this highly acid medium may have had some influence on germination of the parasite. Therefore a third experiment (*S. hermonthica* only) was started, using a soil of pH about 6.5, obtained from the Sisal Experimental Station, Ngomeni, and confining the *Striga* seed to the upper part of the tube. Another sorghum, received from Northern Rhodesia as "Biennial Sorghum", was included in this test.

In this experiment also only a small proportion of the *Striga* seed germinated and again many of the primary roots of the parasite failed to reach those of the host. but more young *Striga* plants developed in this experiment than in the first two. Once again maize produced a much more extensive root system and far more young *Striga* plants developed on it than any of the sorghums. At the end of the experiment, after 53 days, the intensity of attack, judged by the number of vigorous young *Striga* plants on the hosts, was approximately in the following order: Maize, "Biennial Sorghum," common sorghum, Kalipyaung (see Fig. 2), 37 R 29, 37 R 37 and 37 R 9, maize having very many young *Striga* and 37 R 9 only three. This last sorghum had a very poor root system and very few *Striga* seeds were seen to germinate in its presence, but three strong young plants were found attached to the roots when the soil was washed out.

Bucket Cultures

(*a*) *Main Experiment.*—To make effective tests of the resistance of varieties of sorghum to attack by *Striga* it is obviously necessary to grow them in the presence of a uniform seed population of the parasite. Conditions must also be suitable for the development of *Striga* and for the host plants to reach maturity if not overcome by the parasite. The experiments described were designed to gain information on a suitable technique.

Thirty-six 11-inch buckets were filled with a mixture of soil and compost. Sixteen were sown with 0.4 gms. of seed of *S. asiatica* (quantity determined by the amount of seed available) and another sixteen with the same amount of seed of *S. hermonthica,* leaving four without any parasite. Four different host plants were sown, so that for each host there were nine buckets, four with *S. asiatica,* four with *S. hermonthica,* and one with no *Striga*.

The *Striga* spp. seed used was collected for me by the Agricultural Officer, Shinyanga, and used fresh. The hosts used were:—

(1) Common Sorghum.
(2) Sorghum, Kalipyaung from Burma, reputed to be resistant to *S. asiatica*.
(3) Maize, Hickory King.
(4) Bulrush millet (*Pennisetum typhoideum*) seed from Mwanza.

Twelve seeds of each host species were sown and subsequently thinned to leave three plants per bucket. Some difficulty was experienced in establishing common sorghum (No. 1) as the seed sample was poor.

As the experiment was started during the cold season (June, 1939), and as *Striga* in Usukuma appears naturally during the hotter months (March–April), two buckets of each host and each species of *Striga* were removed periodically from the glass house to a hot chamber maintained at 30° C. The amount of light in this chamber was restricted, and it was found that prolonged confinement produced severe etiolation, hence the adoption of intermittent treatment. Twice a week throughout the experiment the buckets were watered with nutrient solution.

Periodical counts were made of the number of *Striga* plants appearing in each bucket. The

first young plants appeared in the maize culture seventy-five days after the start of the experiment, most of them in the heat-treated series.

This trial ended on 24th October, 1939, when most of the hosts, except maize, had matured heads. Maize did not set seed, as the anthers had all shed their pollen before the silks appeared. A few plants of *S. asiatica* produced flowers in this test; *S. hermonthica* did not flower.

After removal of all *Striga* plants showing above ground level, a second crop of the host plant was then sown in the same soil and with no further addition of *Striga* seed. A few young *Striga* plants appeared before the second crop had become established, but all these subsequently died, indicating they had been attached to the roots of the previous host plants and failed to establish contact with the roots of the young hosts. This second crop was grown during warmer weather and hence without heat treatment.

Many more *Striga* plants appeared on the second crop than on the first, including a number of both species on Bulrush Millet (*Pennisetum*). All *Striga* plants on this host were, however, greatly dwarfed throughout their life; only *S. asiatica* reached the flowering stage, whereas on other host plants both species flowered profusely.

In the first experiment there were such wide variations between the numbers of *Striga* plants in buckets of the same treatments that there are obviously no statistically significant differences. Although in general many more *Striga* plants appeared in the buckets receiving heat-treatment, contradictory evidence is obtained with the sorghum—*S. hermonthica* culture.

The results from the second crop showed, on analysis, a significantly higher number of *S. asiatica* plants on common sorghum than on any other host, a mean of 238 per bucket compared with 76 on Kalipyaung, 37 on maize and 14 on bulrush millet. The number of plants of *S. hermonthica* on common sorghum, 138 per bucket, was not significantly greater than any of the others, 53 on Kalipyaung, 24 on maize, and 23 on bulrush millet.

The only plants producing mature ears in the second crop were the Burmese "resistant" sorghum (Kalipyaung), the *Pennisetum*, and the control in the common sorghum series. Common sorghum plants in the infested buckets were very dwarfed and failed to come into ear. Maize, although dwarfed, produced both the male and female flowers, but failed to set more than one or two seeds owing to the discrepancy in the time of appearance of the male and female organs.

In order to estimate the residual amount of viable *Striga* seed in these cultures all buckets were planted with "Biennial" sorghum, a variety mentioned which has proved very susceptible to attack by both species of *Striga*. First, however, compost, sulphate of ammonia and rock phosphate were added to the exhausted soil in the buckets. Great difficulty was experienced in establishing the host and subsequent development was poor. Only 11 *Striga* plants were recorded over a period of five months (March to August) until the experiment was discontinued. Cold weather may have been a contributory factor to poor growth of the hosts plants and also the *Striga*.

(*b*) *Biennial Sorghum*.—Under Amani conditions and the cultural methods adopted, this variety received from Northern Rhodesia under the name "Biennial sorghum", crops in six months. Two buckets were sown with seed (O. 4 gm.) of *S. asiatica* and *S. hermonthica* in November, 1939, 22 days after the host seed. The first young *Striga* plants appeared in the middle of December, 41 days after sowing. Thereafter development was rapid and by the end of the year there were numerous young *Striga* plants in each bucket. At the end of the experiment (February, 1940) the two buckets planted with *S. hermonthica* had an average of 216 live plants and many that had wilted; those planted with *S. asiatica* had an average of 556 plants. The hosts were very sickly. The susceptibility of this variety to *Striga* attack suggested its use in the experiment described above. It was also used as a control in the experiment next described.

(*c*) *Trials of Resistant Sorghums*.—In February, 1940, the hot season, new series of bucket cultures was started to test resistance to *S. hermonthica* of varieties of sorghum reputed to be resistant to *S. asiatica*. The varieties tested were 37.R.9, 37.R.29, 37.R.37 from South Africa, two buckets of each, and Kalipyaung from Burma (one bucket). Biennial sorghum (one bucket) was used as control.

As tube cultures had indicated a better germination of *Striga* seed in soil with pH 6.5 from the Sisal Experimental Station, Ngomeni, this soil was used in the buckets for this experiment. The *Striga* seed used was from Ukiriguru and had been stored in an airtight glass tube for nine months.

Counts of *Striga* plants to 4th May, 1940, were as follows:—

Biennial sorghum ..	241
Kalipyaung	74
37.R.9	112 (av. of two buckets)
37.R.29	201 (av. of two buckets)
37.R.37	181 (av. of two buckets)

All host plants were severely damaged by the effects of the *Striga* and eventually died without flowering.

There were big differences in the numbers of *Striga* plants appearing in the different buckets, although conditions were made as uniform as possible. Little weight can therefore be attached to the apparent differences in susceptibility to attack shown above. New trials with adequate replication are required.

A variety of sorghum called Bongonhilo, originally introduced from Tanganyika, is reported to be resistant to *S. asiatica* in Madras (5.6). Apparently this variety is no longer cultivated to any extent in Tanganyika, but after meeting with considerable difficulty, the Agricultural Officer, Shinyanga, was able to send me seed from 17 separate heads for trial. This seed was planted in buckets containing a nearly neutral soil obtained from Kizugu, a sub-station of Amani in the Lower Sigi Valley, where this test was carried out. Three buckets were planted with seed from each head, 51 in all, on 18th October, 1940. Seed from one head did not germinate. *Striga hermonthica* seed, which by this time had been stored for 16 months in an airtight tube, was sown in early November at a rate of 0.4 gms. per bucket, around the young host seedlings. The first young *Striga* plants were observed on the 7th December, and by early January the host plants were for the most part looking very sickly. The *Striga* was flowering by the 27th January, so on that date all visible plants were pulled up, counted and burnt to prevent dispersal of seed. The general mean for the number of *Striga* plants per bucket was 68.8, but there was a very wide range of variability within the varieties (heads) and between the varieties, so that there are no significant differences in the behaviour of the various cultures when judged by the number of *Striga* plants appearing.

The experiment continued after the uprooting of the first crop of *Striga*, weekly counts of new *Striga* plants being continued. Owing to the effects of the primary infestation, on the host plants, many of which were killed, the second crop of the parasite was very much more variable than the first, a general mean of 16.1 additional *Striga* plants per bucket, but a range from 0 to 139 plants in different cultures. The final count was made on 21st March, when the last sorry remnants of the sorghum were cut off.

Penetration of the Host by the Parasite

Microscopical studies of *Striga* haustoria on roots of both susceptible and reputedly resistant hosts show that in all those studied both spp. of *Striga* may penetrate completely, i.e. so that an intimate connexion is established between the conducting tissue of the host and the parasite. The investigations so far made do not, however, reveal the proportion of germinating seeds that penetrate successfully if they come in contact with a host root. In material from tube cultures I have not been able to find any evidence of partial penetration.

Discussion

The results obtained from the tube cultures, using fresh *Striga seed*, show that a small proportion of the seeds of both species germinate in the presence of the host plants which are known to be resistant to attack by *S. asiatica* and that more young plants of *S. hermonthica* were found than of the former species. There is nothing to indicate that the early part of the life history of *S. hermonthica* differs in any essential feature from that described by Saunders for *S. asiatica*. The results from the bucket cultures indicate that there is similar progressive maturation period for the seed of *S. hermonthica* and *S. asiatica* (*vide* Saunders[2]. In the bucket cultures many more *Striga* plants of both species appeared in the second crop than in the first. With fresh *Striga* seed the maximum number of *S. asiatica* plants in any one bucket was 40, on maize; of *S. hermonthica*, 135, also on maize. During the second crop in the same soil the maximum had risen to 400 plants of *S. asiatica* and 185 of *S. hermonthica*, both on sorghum. The *Striga* seed sown in the experiment with "Biennial sorghum" was six months old (stored in an airtight tube for this period) and a maximum of just under 600 plants was recorded for *S. asiatica* and just over 300 for *S. hermonthica*. This host, however, seems very susceptible to attack by both species.

I am not aware that any investigations have been made on the effects of intensity of attack on the parasitized roots. It may well be that a severe infestation of roots of the host may so interfere with their normal function that they succumb and the parasite with them before secondary haustoria, connecting with other

roots, have developed enough to enable the young parasite to continue growth. Saunders points out that many *Striga* plants do not develop to the stage when they appear above ground and also that the rapidity of development of the parasite is related to their numbers and the available food supply of the host.

Accepting Saunders' figure for weight of seed of *S. asiatica* (and seed of *S. hermonthica* is similar in size) the 0.4 gms. of seed sown in each bucket contained about 90,000 seeds. Comparison with the figures quoted above shows that only a very small proportion of the *Striga* seeds produce plants appearing above ground. The final test in the bucket cultures, with a susceptible host, failed to reveal any large residual stock of viable *Striga* seed, but the soil was probably so exhausted, in spite of the manures applied, that the host itself did not develop vigorously enough to support adequately any developing parasites. Another contributory factor was probably the low temperatures experienced during the test.

In spite of the lack of statistically significant differences in the number of *Striga* plants appearing in the main experiment, one was inclined to accept as a basis for further work, the evidence of partial resistance, or at least tolerance, of Kalipyaung, which gave a small crop in the presence of a large potential infestation. However, the final test of resistant forms, using nine-months-old *Striga* seed, did not confirm this evidence. It therefore appears hazardous to proceed with selection of resistant forms before prolonged tests with the material have been made.

The efficiency of the methods used at Amani is not very high as it has been found necessary to renew soil in buckets, and consequently the population of seeds of the parasite, at frequent intervals. It therefore appears necessary to continue this work in the field where natural and controlled infestations of the parasite can be studied without the necessity for the arduous precautions to prevent accidental distribution of the parasite in clean areas. This means, however, that only one crop per year can be grown instead of the several that can be obtained under artificial conditions.

Another point arising from these experiments may have some bearing on the observation mentioned in the introduction, the influence of manuring on the incidence of *Striga* in the field. The vigorous growth of the host plants in fertile soil may enable them to escape or tolerate a moderate infestation and also, by shading the soil, reduce temperatures below the optimum for germination of the *Striga* seed. This aspect of *control,* however, needs further investigation as it is probable that the vitality of *S. hermonthica* seed is similar to that of *S. asiatica.* Seed of the latter can remain in viable condition in the soil for a number of years and the essence of control is to provide for the germination of the seed combined with measures to prevent development of the plants to the seeding stage.

Experiments with bulrush millet at Ukiriguru have shown that this crop can be grown satisfactorily on some of the heavier soils. As this crop has shown partial resistance to infestation with *S. hermonthica* it may prove valuable in suppressing the pest in some of the more seriously infested areas. Further trials are, however, necessary to determine whether *S. hermonthica* seed will germinate freely in its presence.

Conclusions

1. Germination tests of *Striga* seed in the presence of host plants do not give an adequate criterion of resistance.

2. Age of the seed and temperature appear to be important factors in germination tests with *S. hermonthica* as has been shown for *S. asiatica.*

3. The reaction of the soil appears to have some influence on the germination of seed of *S. hermonthica,* although this is probably through the preference of the host. Better germination was found in cultures with a nearly neutral reaction than in a highly acid medium.

4. There is no evidence that resistance to *S. asiatica* indicates resistance to *S. hermonthica.*

5. Repeated tests are necessary before reliable evidence of resistance can be obtained.

REFERENCES

[1] Saunders, A. R., 1933, Studies in Phanaerogamic parasitism with particular reference to *S. lutea Lour. Union of S. Africa, Science Bull.* 128, 1933.

[2] Rounce, King and Thornton, Agricultural Investigations in Usukuma and Unyamwezi. (Unpub.)

[3] Reports Department of Agriculture, Burma, 1936-37 p. 198, 1937-38 p. 210, 1938-39 pp. 199-200, 1939-40 p. 212.

[4] Saunders, A. R., 1940, Breeding Sorghums resistant to witch-weed. Ann. Rep. 1939-40, Field Husbandry Research Section Coll. Agri. Potchefstroom.

[5] Rangaswani Ayyangar, G. N., Ann. Rep. Millets Specialist. Rep. Subord. Officers, Dept. Agric., Madras, 1937-38 p. 126.

[6] Rangaswani Ayyangar, G. N., Ann. Rep. Millets Specialist, Coimbatore; 1938-39. G.P. Madras, 1940.

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TRANSPLANTING BUDDED PLANTS OF ALEURITES MONTANA

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Introduction

The budding of tung trees is at present only in the experimental stage and no yield figures are available from established clones. It seems likely, however, that budded plants of the species *Aleurites montana* will be planted fairly extensively in the relatively near future, and experimental plots of such material have already been planted on a number of estates in Nyasaland. A field of buddings may either be established in situ on seedling stocks planted a year before, or from budded plants raised in the nursery and subsequently transplanted. At the present stage it is not possible to say which procedure will prove to be the more satisfactory on a large scale, but probably both methods will be used to some extent. Budding in the field is quite straightforward and not particularly difficult provided good stocks and budwood are available. Where the budding is done in the nursery the plants may either be cut back, to force the bud patch into growth, and transplanted at the end of the following dormant season when the scion has made a foot or two of growth, or they may be transplanted as "stumps" shortly after budding, before the scion bud has grown out. In the former method the plants may be difficult to handle owing to the rapidity with which the scion grows in the nursery, they must be planted under rather dry conditions, and they will be put out some months later than if transplanted as stumps. There is little doubt that transplanting as stumps will be easier, cheaper, and more effective. It is a method already extensively used in establishing seedling plantations and has given good results.

Two fields at the experimental station were planted with budded stumps at the beginning of the rains in 1940. The plants were lifted carefully from the nursery, cut back four to six inches above the bud patch and the roots pruned lightly, the tap root to 18 inches and the lateral roots to nine inches. Quite satisfactory results were obtained, the stumps being easy to transport and plant and the number of deaths low. It was necessary, however, to remove any stock buds which grew out after planting and this meant that the plants had to be periodically examined for some time as many of the scion buds were rather slow in starting growth and took a long while to establish dominant shoots. It was in an attempt to find the best means of forcing the scion bud into early and vigorous growth after transplanting that the experiment described below was carried out.

Description of Experiment

A number of fairly uniform *montana* seedlings were budded in the nursery with budwood from six mother trees, the buds being inserted by the modified ForKert method at one inch above ground level. Budding was done in September on the resumption of growth after the dormant season, and the stumps were transplanted at the beginning of the rains in December. The same person budded all the stocks. Three different types of treatments were applied to these plants either at or before the time of transplanting:—

C.0 Stocks cut back at time of transplanting.

C.1 Stocks cut back eight days before transplanting.

C.2 Stocks ringbarked eight days before transplanting.

P.0 Stocks cut three inches above bud patch.

P.1 Stocks cut one inch above bud patch.

R.0 As much root as possible left on the stump: tap root pruned at 18 inches, but lateral roots only pruned if very long, and fibrous rootlets left.

R.1 Roots pruned hard—tap root cut at 18 inches, laterals cut back to three inches, fibrous rootlets removed.

Each of the 12 possible combinations of these treatments was applied to 18 plants and the total of 216 were transplanted to form a 3 x 2 x 2 factorial experiment (partially confounded) with the twelve treatments replicated three times in three main blocks of twelve plots. Each plot contained six plants—one budding of each of the mother trees, so that all the plots were identical as regards scions. The effect of the treatments C1 and C2 was to cause the scion buds (and usually some stock buds as well where the cutting or ringing was done 3 inches above the patch) to swell and commence growth before transplanting. The time of eight days was arbitrary; after this time most of the buds had swollen and had they been left longer some would have made shoots

which would easily have been broken in transporting the stumps. In other batches of stumps which have been planted more recently the buds did not push for 12 or 14 days. Plants which were ringbarked or cut before transplanting were done at the height at which they were finally to be cut back, i.e. either one inch or three inches above the patch. The stumps were replanted at a spacing of five feet square in a multiplication nursery at some distance from the original nursery. They were carried in bundles wrapped in grass and no damage was done to buds that had begun to grow.

Results

1. *Percentage of Successes.*—Ninety-six per cent of the plants rooted and produced shoots from the bud patch. There were no significant differences in this respect between treatments.

2. *Time taken by the Scion bud to commence growth.*—The stumps were examined every other day and any stock buds which commenced growth were rubbed off. At the same time the number of days which elapsed after planting before the scion bud commenced growth was recorded. The mean values obtained are summarized in Tables IA and IB, and the significant differences may be expressed as follows:

(*a*) Cutting back eight days before transplanting caused the buds to shoot ten days earlier than ringbarking before transplanting (significant at p = 0.01) and three weeks earlier than cutting back at the time of transplanting (significant at p = 0.01). The difference between C2 and C0 is also significant.

(*b*) With plants cut back eight days before transplanting it made no difference whether they were cut three inches or one inch above the patch since the scion bud usually grew away rapidly before any stock buds pushed out. But with plants only ringbarked before transplanting, or cut when lifted, cutting one inch above the patch caused shooting to occur fourteen and eight days respectively earlier than cutting three inches above the patch (significant at p = 0.01). This, of course, was due to the delaying effect of stock buds pushing out from the snag above the patch.

(*c*) Root pruning did not affect time of shooting where plants were cut low, but slightly delayed it (by 3–7 days) where they were cut three inches above the patch. (Significant at p = 0.05.)

Table 1—Time (in days) taken by scion bud to commence growth

TABLE IA

	Cut at transplanting C0	Cut before transplanting C1	Ringbarked before transplanting C2	Mean
Cut three inches above patch—P0	38·23	14·75	30·78	27·92
Cut one inch above patch P1	30·07	12·08	17·18	19·78
Mean	34·15	13·41	23·98	—

TABLE IB

	Roots left	Roots pruned	Mean
Cut three inches above patch—P0	26·07	29·78	27·92
Cut one inch above patch —P1	19·79	19·77	19·78
Mean	22·93	24·77	—

Significant difference between means of—

6 plots = 5·79, p = 0·01

9 plots = 3·46, p = 0·05

12 plots = 4·10, p = 0·01

18 plots = 3·34, p = 0·01

3. *Scion growth during the first season.*—During the dormant season the length of scion growth made by each plant during the first growing season was measured. This gave a fairly accurate comparison of growth as no branching had occurred. Owing to the deficient rains growth was less than that usually obtained, although the plants did not suffer seriously from drought. The mean values which are of interest are shown in Table 2.

TABLE II

SCION GROWTH (In Inches)

	Cut at transplanting C0	Cut before transplanting C1	Ringbarked before transplanting C2	Mean
Cut three inches above patch—P0	13·32	19·32	15·27	15·97
Cut one inch above patch—P1	13·63	19·95	18·58	17·39
Mean	13·47	19·63	16·92	—

Significant difference between means of—

12 plots = 2·38, p = 0·01

18 plots = 1·31, p = 0·05

The results are similar to those obtained above for the time taken by the scion to commence growth:—

(a) Plants cut back eight days before transplanting have made significantly greater growth than those ringbarked or cut only when lifted. (Significant at $p = 0.01$). The plants ringbarked before transplanting have also made better growth than those cut at lifting ($p = 0.01$).

(b) Cutting one inch above the patch has resulted in greater scion growth than cutting three inches above the patch. (Significant at $p = 0.05$.)

(c) There is no significant difference between root treatments and no significant interactions. (R0 — R1 = 17.31–16.04 = 1.27. Significant difference = 1.31.)

4. *Health of Plants.*—At the time of transplanting no protective paint or other material was applied to the cut surfaces of the stumps and the "snag" were allowed to remain until the beginning of the second season's growth. They were then removed by a cut made at 45 degrees, the upper side of which coincided with the junction of the upper side of the scion and the stock. In all cases it was found possible to make this cut down to living wood and no rot appeared to have penetrated below into the stock, or into the scion. There, therefore, appears to be little risk of disease entering the plant even when the original cut is made only one inch above the bud patch.

Conclusion

Judging from the results given above it appears that budded plants of *A. montana* may be successfully and easily transplanted as stumps, and that in order to obtain rapid and vigorous growth of the scion the stocks should be cut back one inch above the bud patch some days before transplanting, so that the scion bud is in an active condition before lifting. Root pruning should be confined to removing only inconveniently long roots.

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FRUITY 17th CENTURY COMPOSTS

So long ago as 1675, John Evelyn read before the Royal Society "A Philosophical Discourse on Earth, Relating to the Culture and Imrovement of it for Vegetation". Particularly interesting at the present time are the two pages devoted to the methods of making compost. This is the name given to the rotted vegetation by Evelyn, showing that the name of the product, as well as the method of preparing it, are a good deal older than those who have only thought of it since the scarcity of farmyard manure may imagine. Evelyn gives one of our up-to-date arguments for compost-making: destruction of vermin, weeds and fungus diseases by the heat engendered.

Evelyn suggests a pit four feet deep, built under cover, with the bottom capable of holding water; to this run channels from stables and house sinks. The materials should be first a layer of stable litter, then a layer of fine mould covered by a layer if cider mash, rotten fruit and garden offal. On this place a couch of pigeons' dung and more stable litter with earth. Then comes a layer of cow dung, ashes, soot, fern, wood slack, sawdust and the dry scourings of ponds, with all other ingredients as they are amassed. Plentiful water, from a pond in which cattle drink, should be poured over and the pit left for two years. The mass is then to be mixed as removed from the pit, sifted to remove unrotted material and stirred frequently until sweetened.

The above was known, for distinction's sake, as the dry mixture, but there is also described the making of a liquid mixture. A pit or cistern was sunk in a pergola or shed, built between east and north. Into this pit was cast all the acid plants and rank weeds such as hemlock, docks, thistles, cabbage leaves and stalks, aconites and leaves, with any trash which cattle refuse to eat. Then were added pigeon dung, ashes, feathers, soot, hair and bones, and the whole kept moist with urine, blood, pickle, brine and sea water. When the mass was "consumed", the addition of liquids was stopped and the mixture allowed to dry. A further way of using this compost was to boil it into "Petre", a spirituous substance which Evelyn frequently refers to, and which was said, when used in small quantities, to give better effects than great quantities of dried compost.

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MODERN METHODS FOR THE CONTROL OF MOSQUITOES AND MALARIA*

PART II

By G. H. E. Hopkins, M.A., Senior Entomologist (Medical), Uganda Protectorate

ARTIFICIAL MEASURES AGAINST LARVÆ

As artificial measures I have chosen to consider those methods which aim at getting rid of bodies of water completely, and those which employ chemicals to render water unsuitable for the breeding of malaria vectors. Obviously the division between artificial and naturalistic measures cannot be clear cut: there is little essential difference between fouling the water with chemical substances produced by nature, as in "organic pollution," and spreading oil or paris green on its surface; the main difference is that nature produces more permanent (but in this case more selective, and therefore somewhat less satisfactory) control. Similarly, there is no very great difference in principle between drying an area of swamp by means of ditches and using trees to produce the same effect; afforestation of swamp uses both these methods, with the addition of the purely naturalistic measure of shading residual water to render it unsuitable for malaria vectors.

The choice between naturalistic and artificial measures of control is governed by the results with which we are prepared to be content and by financial considerations. It has been well said by Sir Malcolm Watson that a malariologist need not necessarily suffer from hydrophobia, but in my opinion a medical entomologist, *when dealing with townships,* should suffer from at least a touch of this disease. The medical entomologist should not regard mosquitoes solely as malaria vectors, but must take into consideration the fact that some of them are vectors of other diseases and even that, regarded solely as a nuisance, the species which bite man may lower his general health and thus produce conditions favourable to his falling a victim to diseases with which mosquitoes have no direct concern. Our aim should therefore be to exterminate all mosquitoes which bite man, but in rural areas this is at present quite impossible and we must decide whether or not we are to be content with abolishing malaria; in the vast majority of cases financial considerations will force us not only to be content with this but even to be highly delighted if we succeed in accomplishing it. In general, the position will be that in townships, where the extra cost of mosquito control, as against control of malaria, is not great (especially now that *Stegomyia* control has become important), we attempt to abolish all breeding places of mosquitoes which bite man, whereas in rural areas we consider only malaria, and use naturalistic measures which are commonly very much cheaper but make no pretence to do anything more than get rid of vectors of malaria.

Artificial measures divide naturally into permanent and temporary methods, the former comprising such methods as filling and draining and the latter the use of such substances as oil and paris green. The choice between permanent and temporary measures is largely dictated by financial considerations: permanent measures often involve heavy capital expenditure but cost little or nothing to maintain; temporary measures are infinitely cheaper in the first place but must be kept up indefinitely and are usually much more expensive in the long run. A further grave disadvantage of temporary measures is that any breakdown in the arrangements for supervision of the work (such as may be caused by diversion of staff to war service or to control of an epidemic of smallpox) may result in a partial breakdown of the control maintained by temporary measures and a resultant increase in malaria. My opinion is that, save in exceptional circumstances where permanent measures would (for some special reason) be inappropriate, temporary measures should always be regarded solely as a stopgap to be used until sufficient money to carry out permanent measures becomes available.

Filling

An enormous proportion of malaria in East Africa is man-made, the main breeding places of the vectors having been produced by man. The European or Indian requires clay for bricks, murram to make roads, or gravel from which to extract gold, the African wants clay and sand to use in the construction of his house, and a convenient source of water. All of them therefore dig holes, and none of them normally dream of filling the holes up again when no longer required. The holes soon fill with water, malaria vectors breed in them (*gambiae* when the holes are newly abandoned and *funestus* as they become overgrown with

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vegetation), and malaria results. The very obvious remedy is that all holes should be filled up again the moment they are no longer required.

Round many townships excavations of this nature are so extensive that filling material is difficult to obtain in sufficient quantity without bringing it from a distance and thus greatly adding to the expense. For such cases township refuse is invaluable as filling material; it should never be wasted while any excavations remain to be filled.

Natural hollows can also often be dealt with by filling, though some are so large that drainage must be employed. Since ditches are apt themselves to become breeding places of malaria vectors, draining should never be resorted to until filling has been considered and rejected as impracticable.

In occasional areas (Tororo, for example), holes in rock may be very important breeding places of malaria vectors. At Tororo there are extensive areas of sheet rock covered by a thin "skin" of earth and grass. If for any reason this skin is removed, the larger of the holes thus produced become eminently suitable for the breeding of *Anopheles gambiae*; hollows in bare rock may also produce considerable numbers of this species. Such breeding places were very largely responsible for the former evil reputation of Tororo for malaria. They were dealt with either by filling with stones covered by a thin layer of concrete, or by filling with earth and allowing grass to grow over the earth and re-form the protective "skin" of turf, the former method being used for holes in bare rock. Shortly after most of the breeding places at Tororo had thus been dealt with a local medical practitioner complained bitterly of the consequent reduction in the value of his practice.

A type of breeding place to which altogether too little importance is usually attached is the shallow temporary rain pool, especially puddles and car ruts on a road. Possibly in the drier parts of East Africa these may not persist long enough for breeding to be completed, but during the wet season in Uganda they often last amply long enough for this. Casual inspection of such pools often suggests that they are harmless, whereas if the mud at the bottom be stirred up larvæ of *A. gambiae* will come to the surface in dozens. Filling these puddles as they appear is the obvious remedy.

Draining

I have already mentioned that the best method for dealing with borrow pits and other excavations is to fill them up. But occasional cases occur in which a very large excavation, which would be very expensive to fill, can be drained by means of a very short ditch. Similarly, afforestation is the method of choice for dealing with seepages, but in some instances it may be necessary to deal with them by draining. The most frequent type of case in which we must resort to the use of drains or ditches is in dealing with small streams which must be converted into ditches by canalization.

The fact which should be ever in our minds when considering the use of ditches is that ordinary open earth ditches are in themselves important sources of the vectors of malaria. They commonly begin by being narrow, with good banks and a good flow of water, so that breeding of Anophelines is temporarily prevented. But after a very short lapse of time bank falls invariably take place, and we are faced with the dilemma: to clean or not to clean. If the ditch is not cleaned out stagnation takes place above the bank falls and breeding of vectors occurs, so cleaning is undoubtedly the lesser of the two evils. But repeated cleaning inevitably widens the channel until it becomes too wide for the volume of water, pooling occurs, and breeding of malaria vectors results. Is it surprising that experienced malariologists in East Africa have a horror of earth ditches and regard them as cheap and very nasty? Cement channels avoid most of the drawbacks of earth ditches, but are expensive; in the case of fairly large streams we may have no alternative to using them unless we are to go on oiling the stream to all eternity. The cement need not necessarily extend to the top of the channel, but must extend well above the dry-season level of the water; above this point the sides of the channel must be well sloped to minimize bank falls, and should be grassed for the same reason. Even with this type of channel, bank falls are liable to occur, owing to tearing away of portions of the bank by storm water, but they should not be numerous and are easy to repair.

If the volume of water is very small, either permanently or at all times except when there are violent storms, the best method of dealing with small streams is undoubtedly to put them underground, and in districts where agricultural drain-tiles can be obtained cheaply they should be used. Unfortunately, transport costs usually render these tiles very expensive in East Africa. The method is to bury the tiles sufficiently deeply to prevent roots growing

into them and causing a blockage, and to leave a channel, shaped like a very shallow U, on the surface. The channel is allowed to become overgrown with grass (to minimize erosion) and takes storm water, while the normal flow goes through the tile drain.

Where drain-tiles are prohibitively expensive rubble drains form a very fair substitute. They are constructed in the same way as tile drains, but a channel filled with rough stones, preferably about twice the size of a man's fist, replaces the drainpipe. The length of life of rubble drains before they become choked with silt depends mainly on the texture of the soil, but in several stations in Uganda such drains have now been in use for many years and have given practically no trouble. If suitable stones are readily available, the cost of making such drains is very little more than that of earth ditches, and the cost of upkeep is negligible.

Larvicides

Many substances have been recommended for application to water in order to kill mosquito larvæ; some have been found ineffective in East Africa, others are still in the experimental stage or unobtainable here, and only three will be dealt with below. Of these, the best-known are anti-malarial oil and paris green.

These two larvicides are applied in different ways and have different effects. Paris green is mixed with a "carrier" of dust or wood ash at the rate of 2 or 3 per cent paris green by volume (1 per cent has been suggested, but has not given satisfactory results in Kampala), and dusted on to the surface of the water by means of a knapsack duster; the carrier sinks and leaves the paris green floating on the surface of the water, where it is devoured by the surface-feeding larvæ of Anophelines, which are thereby poisoned; Culicine larvæ, which feed below the surface, are not affected.

Suitable anti-malarial oils are obtainable, ready for use, from the oil companies. Although there is little doubt that the requirements for an effective oil vary from district to district (so that by detailed experiments in each district it would be possible to devise a home-made mixture which would be more suitable for use in the district than the proprietary mixtures), it is very doubtful if any consequent increase in efficiency or saving in cost would be sufficient to justify the amount of work involved in devising such mixtures. The oil is sprayed on to the water by means of a knapsack sprayer, and forms a film over the surface, which kills the larvæ of both Anophelines and Culicines. It kills partly by suffocation and partly by poisoning, and it is the latter factor which causes the great variations in effectiveness between different oils; some having practically no poisoning effect.

The question of whether oil or paris green should be the larvicide to be employed is a highly controversial one. The only advantages claimed for paris green, so far as I am aware, are that it is of value amongst dense vegetation, where oil cannot penetrate, and that it is much cheaper ("less than half"). Against the first of these claims it may be remarked that regular application of oil will kill the vegetation, and I dispute the statement that, if the two methods are to be applied with equal efficiency, the use of paris green is significantly cheaper than that of oil, *in East African conditions*. In this connexion the fact that no East African territory has adopted paris green as its standard larvicide is probably highly significant.

The first objection to the use of paris green (I omit the fact that it does not kill Culicines, because some malariologists would not consider this a valid objection) is the difficulty of finding a suitable carrier. Road dust in many areas in East Africa contains too much very fine sand to be suitable for the purpose, whereas wood ash remains afloat too long, so that the larvæ devour large quantities of this and very little paris green; it is probably for this reason that 1 per cent by bulk of paris green was not satisfactory in Kampala and 2 per cent had to be used to get a good kill. A more serious objection is with regard to supervision, always one of our greatest difficulties in East Africa. As paris green is highly poisonous, European or Indian supervision is essential for the mixing process, whereas no mixing is required in the case of oil. Furthermore, paris green is not very easy to see on the surface of the water, even when freshly applied, and is almost invisible when the carrier has sunk, whereas oil is conspicuous. This would not matter if the labour employed were reliable, but it is far from unknown for oiling gangs to dump all the oil in one or two pools and spend a restful day in consequence, while even quite good gangs will oil the majority of the pools and overlook many others. With oil, a very rapid check will reveal such failures, but with paris green a much more careful check is necessary, which must be made before the carrier has sunk. Much more

time must therefore be employed on supervision if paris green is used. In calculating the relative costs of the two methods this factor is almost invariably ignored, probably because most of the malariologists concerned are working with far more reliable labour (European or Asiatic) than is available to us. If this factor is taken into account I greatly doubt if paris green is any cheaper than oil.

A further serious objection to the use of paris green in East Africa is that it is only effective while floating on the surface. The heavy rainstorms so frequent with us during the period of maximum breeding of Anophelines cause it to sink and become ineffective. Furthermore, it does not kill pupæ, so the period between applications needs to be shorter than in the case of oil.

In view of the difficulty of obtaining anti-malarial oil under present conditions, an alternative larvicide is worth mentioning, even though its use is still not entirely out of the experimental stage. This is cotton-seed "tar", and is a waste product of those cotton ginneries which use producer-gas engines. Its possible larvicidal value was suggested by the observation that in a stream which received the effluent from such a ginnery Anopheline larvæ were to be found above the outlet pipe but not for a considerable distance below it. Experiments showed that, in order to pass freely through the jet of the sprayer and to spread evenly over the surface of the water, the cotton-seed tar must be mixed with kerosene in the proportions of not less than one volume of kerosene to three of the tar. The two liquids mix readily, but the mixture must be filtered through ordinary wire mosquito-gauze before use, so as to remove solid particles which would block the jets of the sprayer. "Voco" kerosene was used in our experiments, and it cannot be stated definitely whether other kerosenes would or would not be satisfactory, because kerosenes vary greatly in the properties which make them valuable as part of a larvicidal mixture.

After preliminary tests in glass jars to see if cotton-seed tar had much larvicidal action, the experiments in Kampala were conducted in pits, in each of which the water surface was about 14 square feet. The killing power of the cotton-seed tar mixture was tested against that of anti-malarial oil applied at the same rate. The two mixtures were found to be practically identical in larvicidal action. The cotton-seed tar has an objectionable smell, but this is not necessarily a disadvantage, because it may tend to deter egg-laying by mosquitoes. The mixture with kerosene is very much cheaper than anti-malarial oil. A large-scale experiment on the control of mosquitoes by use of the cotton-seed tar mixture is at present in progress.

In the case of all larvicides the period which may safely be allowed to elapse between applications is of great importance if economy is to be combined with efficiency; it is obviously wasteful to apply larvicides once a week if once a fortnight would suffice. This period is governed by climate, which directly affects the length of the early stages of mosquitoes, and by the species of mosquitoes concerned, since different species may have very different periods of pre-adult life. Furthermore, development is usually more rapid in the hot season than at other times of year. Taking the case of *A. gambiae* as an example: in Nairobi it has been shown to have an average pre-adult life of 18 days, varying from 12 days in March to 24 and 26 in July and August; in Kampala, where the climate is much hotter, a few observations made during the cool season showed a pre-adult life for this species of from 12 to 15 days, while in Lagos (hotter still) full development from egg to adult may take as little as 7 to 8 days. Simultaneous observations on *A. funestus* in Kampala gave a pre-adult life for this species of 20 to 21 days, or nearly twice as long as that of *gambiae*. Obviously the period between applications of oil for control of *gambiae* in Nairobi (ten days) would probably be much too long for the same species during the hot season in Kampala, where a week is the maximum time which should be allowed to elapse between applications. On the other hand, if only *funestus* had to be considered, it might be possible to extend the interval considerably. In fact, it is not possible to lay down the maximum safe interval between applications of larvicide (and hence the maximum economy compatible with efficiency) without prior study of the species of malaria vectors and their periods of pre-adult life in each district concerned. I have already mentioned that the fact that paris green does not affect pupæ necessitates a shorter period between applications than in the case of oil; as (in Kampala) the pupal period of both *gambiae* and *funestus* is from 2 to 3 days, the period which may safely be allowed to elapse between applications of paris green is at least three days shorter than the period permissible between applications of oil. With the cotton-seed tar mixture the safe intervals would be the same as with oil.

Conclusion

In the above pages it has not been possible to do much more than give a very brief outline of the ways in which we tackle the control of mosquitoes which carry malaria, together with a few practical hints on points which are not dealt with in most books on the subject. I have tried, in particular, to indicate to the layman the principles involved and some methods which he might use to reduce malaria in the absence of skilled advice. But I would emphasize once more that there are a number of experienced malariologists in East Africa, part of whose job it is to advise on such subjects. Anyone who fails to make use of such assistance, when available, runs a serious risk of wasting his money on measures which will not improve the situation and may even make it worse.

EMPIRE PRODUCTION OF DRUGS

IV—LITMUS

By P. J. Greenway, Systematic Botanist, East African Agricultural Research Station, Amani

From the lichens known as Orchella Weeds the colouring materials Litmus, Archil or Orchil and Cudbear are obtained. The most important of these lichens in East Africa are species of *Roccella* and others used in Orchil manufacture are species of *Ramalina*.

The colouring materials are listed in the British Pharmaceutical Codex, but none of them are drugs in the strict sense of the term, Litmus is a violet-blue colour, used as an indicator in various chemical processes especially to determine the alkaline or acid nature of liquids. It is turned from blue to red by acids and the red colour is restored to blue by alkalis. Orchil or archil is a purple dye obtained in three forms, extract, crystals and powder. It is expensive and perishable and is used as a dye for cloth, wools, and silk. The powder is also known as cudbear, which is a purplish-red, imparting a rich red colour to acid and neutral liquids, and turning purple when alkalis are added. It was used as a colouring agent, especially in the preparation of syrups having an acid reaction.

Of those species of *Roccella* found in East Africa *R. Montagnei* Bél. appears to be the most common. Others which have been recorded in Tropical Africa are *R. flaccida* Del., *R. fuciformis* DC. and *R. tinctoria* DC. They are small, bushy, grey or grey-green lichens with strap-shaped or string-like fronds growing on rocks, stones, trees and bushes down the East African coast and occasionally inland. They are generally more common in the low-rainfall areas of the coastal fringe.

Of the genus *Ramalina* some twelve species have been recorded from all over East Africa, where they appear to be more common in mountainous districts from 3,000 to 14,000 ft. They look rather like the Usneas, the familiar "Old Man's Beard" lichens, which are of no commercial importance.

History of Orchella Collection and Export

In 1869, Sir John Kirk refers to the export of Orchella Weed from Zanzibar, but he does not state how much was sent out of the island. According to Stuhlmann, in 1896 Orchella to the value of £1,500 was exported from the island. This may have been the peak period, because by 1904 and 1905 the value had dropped to half. In London in 1891 and 1892 the dried weed was valued at about Sh. 18 to 22 per cwt., a little higher than in 1905 in Hamburg, where 10,300 kgs. were imported from Zanzibar during the year.

Although the bulk of East African Orchella Weed came from Zanzibar it was a product of the mainland, the island being the chief port of shipment in those days. The Blue Books and Trade Returns for East Africa do not indicate whether Orchella Weed is still exported, though some may be masked under the heading "Other Goods Unmanufactured".

In the past the export of Orchella Weed from Zanzibar was a notable item in the island's commerce and the industry, which appears to have been in German hands, employed for some 15 to 20 years, three to four hundred women and children whose task was to sort, clean and bale the weed as it was brought in from the mainland.

Main Sources of Supply

The main commercial supplies of Orchella Weed in East Africa appear to have been col-

lected along the coast north of Malindi, Kenya Colony, thence up to the Juba River in what used to be Jubaland, and possibly into Italian Somaliland.

According to the scanty reports available, the collection of Orchella Weed was a dry-season occupation of the Wabajun, when their seasonal cultivation was at an end, and possibly of the Wabarawa. It could apparently be obtained in any quantity.

Its native names are *Marere* or *Malele* and it is further distinguished as *Marere ya mrima* ("coastal *Marere*"), *M. mayani* (*majani* = "leaves") and *M. ya Barawa* ("of the Wabarawa").

The Wabajun collectors, who do not seem to have remained in the Orchella Weed districts when the collecting season was over, sold the weed to Indian merchants living at Mombrui and Malindi, who then shipped it to Lamu and Zanzibar.

Present Position

According to recent information received, Orchella and its products Litmus and Orchil are likely to be in somewhat short supply in the United Kingdom. The demand is limited, but prices are said to be round about 4/6 per lb. for crude Litmus cake and £40 to £60 per ton of dried *Roccella.*

It has been suggested that to overcome shipping difficulties crude Litmus cake should be manufactured in East Africa in preference to shipping a bulk of *Rocella.* The chief chemicals used in its preparation are ammonium carbonate solution, which has to be imported, and potassium carbonate, which might be manufactured locally. The lack of ammonium carbonate might be overcome by returning to the old method of manufacture by the use of stale urine.

Manufacture of Crude Litmus Cake

In Europe this seems to be a comparatively simple chemical process. The cake appears on the market as small blue cubes composed of gypsum and chalk mixed with a comparatively small quantity of colouring matter, which is present in the form of a lake and was prepared almost exclusively in Holland.

Its preparation is carried out in horizontal or vertical cylinders fitted with stirrers and openings for the admission of air. The Orchella is ground and mixed with half its weight of potassium carbonate and then repeatedly moistened with ammonium carbonate solution or stale urine. The mass should become brownish-red in three days, gradually turning purple in 20–25 days and blue in 30 days. The best quality Litmus is obtained after 40 days. The pulpy mass is mixed with chalk and gypsum, pressed into cubes and dried. Sodium carbonate may replace potassium carbonate, and the presence of these alkalis results in the reaction producing first orcein, and later azolitmin, the principal colouring matter of Litmus, the alkali salts of which are blue in solution.

BIBLIOGRAPHY

Engler, A. (1895).—*Die Pflanzenwelt Afrikas und der Nackhbargebiet*: *Deutsch-Ost Afrika* V. A. & B. Berlin.

FitzGerald, W. W. A. (1898).—*Travels in British East Africa, Zanzibar and Pemba*, London.

Smith, Lorrain (1921).—*Lichens*, Cambridge.

Stuhlmann, F. (1908).—*Beiträge zur Kulturgeschichte von Ostafrika*: *Deutsch-Ost Afrika*, Berlin.

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PRESERVATIVE FOR HESSIAN

A cheap and simple method of protecting jute and cotton sandbags against rotting has been developed by the Imperial Chemical Industries. It is estimated to increase the service life of the bags at least eight times at a cost not exceeding one-tenth of a penny per bag. A Burgundy mixture is prepared by slowly stirring 11½ lb. of washing soda, dissolved in 5 gallons of water, into a solution of 10 lb. of bluestone in 30 gallons of water (using a wooden, not iron, vessel). The quantity is then made up to 40 gallons.

The bags are then immersed until thorough saturation is effected. After the removal of excess liquor by wringing, the bags should weigh twice their original weight. They are dried at low temperature. The period of immersion in cold water should not be less than five minutes, but the process may be expedited by warming the water to 88° to 100° F. Samples of treated fabrics buried in garden soil for eight months were found in excellent condition. The "control" fabrics were almost entirely disintegrated.

N.Z. Agri. Journal, December, 1941.

THE EFFECT OF A LEGUMINOUS COVER CROP IN BUILDING UP SOIL FERTILITY

By G. H. Gethin Jones, M.Sc., Soil Chemist, Kenya Department of Agriculture, Kenya.

The soil type is that of the Kikuyu lateritic red loam, which is the dominant soil of the main coffee areas and of the Native Reserves in the Central Province. The sedentary soil which is derived from porous sub-acid volcanic rocks is of great depth and has very desirable physical properties. Its productiveness depends mainly on the maintenance of the phosphate status and the humus content of the surface soil and the associated supply of available nitrates.

During 1932 and 1933 monthly observations were made on the seasonal moisture content of adjoining soil profiles under different vegetal covers at the Scott Agricultural Laboratories. The treatments comprised two permanent cover crops, two short-term green manures, a vegetable mulch and clean cultivation. This work showed that, under the prevailing conditions, a surface soil under clean cultivation held less moisture at the end of the seasonal rains than a similar surface soil carrying permanent cover crops. Later, during the dry weather, the top-soil of the cultivated soil and to a lesser extent where the green manures had been turned in, lost moisture rapidly at first and then remained about constant, whereas the sub-soil moisture was only slightly reduced. In the cover-crop areas the initial higher amount of water after the rains showed a relatively smaller loss throughout the subsequent dry season of about six months. The outstanding result of these trials was the marked efficiency of a vegetable-mulch in conserving both top-soil and sub-soil moisture.

At the end of this period the performance of *Glycine javanica* as a permanent cover crop was very promising; it made vigorous growth and began to form a litter of decaying debris over a protected, moist, porous immediate surface soil. When the main trials were discarded, this treatment, together with that of the adjoining plot under clean cultivation, was retained for further observations on the role of this leguminous cover crop in building up total soil-nitrogen.

Changes in Total Soil-Nitrogen Status

During the period of the first soil-moisture trials, when very careful periodical replicated soil-sampling was done, certain of the samples were used for the determination of total nitrogen. It was appreciated that any small changes in total soil-nitrogen would be extremely difficult to assess owing to (*a*) small natural soil differences according to sites, (*b*) the difficulty of taking truly representative soil-samples to an exact and uniform depth from a natural soil-surface of varying apparent density, and (*c*) the absolute differences that must obtain before they can be measured by soil analysis. Thus, with ideal sampling and analysis, the addition of nitrogen equivalent to that contained in 200 lb. of sulphate of ammonia or in two or three tons of bulky organic manure per nine-inch acre of surface soil containing, say, 0.200 per cent of total nitrogen would only increase the amount present to about 0.202 per cent. Such a difference is not likely to be greater than the sampling and analytical error. The series of early determinations of total nitrogen for the different plots thus served to give a measure of the variation in total soil-nitrogen content that must be expected with supposed unaltered soils and would indicate the magnitude of difference that in any later determined values could be regarded as significant. The composite samples used were made up of equal weights of six sub-samples taken from the opposite ends of three representative prepared holes. The values for total nitrogen thus obtained from a series of four periodical samplings of surface soil (0–9″) within six different plots is given in Table I.

TABLE I

Percentage Total Nitrogen in Different Plots

Date of Sampling	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6
16–6–32..	·199	·204	·207	·201	·197	·200
14–7–32..	·193	·207	·201	·196	·200	·197
29–8–32..	·210	·205	·223	·196	·204	·199
28–9–32..	·197	·205	·209	·201	·202	·196
Mean ..	·200	·205	·210	·198	·201	·198
S.D. ..	±·006	±·001	±·008	±·002	±·002	±·001

Excluding the high figures for plots 1 and 3 on 29th August, 1932, the differences recorded in any one plot vary between .003 per cent N and .008 per cent N and for all the plots together there is an extreme difference of only .014 per cent N, viz. between .193 per cent and

.207 per cent. The uniformity of the surface soil in this respect is thus clearly shown.

In August, 1936, that is five years after the planting of the *Glycine javanica* cover crop and four years after the above analyses, the soils of this plot and of the adjoining cultivated plot were again similarly sampled for the determination of total nitrogen. By this time the cover crop had a vigorous rooting system and had made a dense tangled growth about one foot high. There were three or four inches of loose litter which was decomposing at its base and the underlying surface soil was very open and appreciably darker than the cultivated soil. The latter had about ceased to carry any weed growth and from now on could be regarded as under a true soil-mulch treatment. In November, 1941, when the cover crop had been established for ten years (nine years after the initial soil analyses recorded in Table I) both plots were once more similarly sampled. By this time the cover crop was still making very vigorous growth, especially in the rainy season. Failing to obtain a hold, the vines fell back in a partially procumbent tangled mass with more upright newer growth. The height was now about 15″–18″ over about 5″ of loose leaf and stem litter, at the base of which there was a distinct zone of partially humified, somewhat earthy compost-like material with active mycelial growth. This layer overlay about ¾″ of a dark, puffed-up soil which was very rich in organic matter and usually harboured an active soil fauna.

The means of the four 1932 nitrogen determinations (omitting the two abnormal values), the 1936 determinations and the 1941 determinations, all based on oven-dried surface soil (0″–9″), are given in Table II. For the last period, the value for total nitrogen based on ignited soil is also given in brackets.

TABLE II

Percentage Total Nitrogen after Different Periods

Date of Sampling	Plot 1 Soil mulch	Plot 3 *Glycine javanica*
Mean of 1932 ..	0·196	0·206
August, 1936 ..	0·198	0·242
November, 1941 ..	0·184 (0·211)	0·270 (0·313)
Apparent difference after 9 years ..	—0·012=6%	+0·064=31%

A separate sampling of the ¾″ layer of the loose soil immediately below the decaying litter showed it to contain as much as 0.477 per cent N in the oven-dried sample, which is equivalent to 0.576 per cent N on the ignited soil.

Table II shows that during the first four years there was no change in the total-nitrogen content of the clean-weeded plot, but that with a soil-mulch instead of weeding during the next five years the total-nitrogen content appears to have fallen slightly—perhaps not significantly. Under the cover crop, there was an increase of 0.036 per cent total nitrogen during the first four years and a further smaller increase of 0.028 per cent N during the subsequent five years, making a total gain of 0.064 per cent N or about 30 per cent of the original content.

It is interesting to convert the above changes into pounds of total soil-nitrogen per acre. A nine-inch sampling of the surface soil indicated its weight to be about 1,820,000 lb. per acre. In 1932, this would have included 3,750 lb. of total soil-nitrogen; in 1936, 4,404 lb., and in 1941, 4,914 lb., thus showing a total gain of 1,164 lb. Without laying stress on these exact figures it can safely be said that during the first five years the mean annual gain was about 160 lb. of total soil-nitrogen and in the last four years 100 lb., an average of 130 lb. over the whole period.

The vigour of growth of the cover crop and the mass of the associated litter have both been steadily increasing. However, it is likely that the continued further accumulation of soil organic matter and its associated nitrogen under the new, undisturbed, cooler, environment is now becoming less marked as equilibrium is being reached under the new edaphic conditions. There is now a marked visible difference between the surface soils of the cover-crop and the soil-mulch plots. The former has a very desirable structure and a much darker colour such as obtains under virgin forest, whereas the latter has become very powdery and more reddish, following prolonged cultivation and exposure without the addition of any form of organic matter.

Changes in Phosphate and Potash Status

As a prolonged growth of the *Glycine javanica* and a determination of its effect on the soil were not anticipated in 1932 when the soil moisture under various surfaces was studied, the phosphate and potash-status of the different plots was not then estimated. This lessens the value of subsequent comparative data for these two nutrients and in the circumstances it is only possible to compare the present values for two different plots, though, as with the total nitrogen values, the phosphate

and potash figures are likely to have been fairly similar for both plots when this trial was started. The phosphoric oxide was removed by extracting and finally leaching 100 gr. of finely ground soil (all passing 40-mesh sieve) with 2,000 ml. of fifth-normal nitric acid. The potash was extracted with 500 ml. of semi-normal acetic acid. The values obtained are given in Table III—phosphoric oxide in parts per million, potash in milligram equivalent per 100 gram of soil and also as percentage.

TABLE III

FINAL PHOSPHATE AND POTASH STATUS OF SURFACE SOIL IN 1941

Plot 1—Soil Mulch		
Phosphoric Oxide p.p.m.	Potash	
	M.E./100g.	As per cent
9·9	1·15	0·054
Plot 3—Cover Crop		
Phophoric Oxide p.p.m.	Potash	
	M.E./100g.	As per cent
19·3	2·04	0·096

Note.—There is need to qualify the figures given in Table III. The quoted values denoting the availability of phoshphoric oxide, which are only about 0.001 per cent and 0.002 per cent for the surface soil, may appear to be excessively low to those not acquainted with the characteristic phosphate status of this lateritic type of red acid soil. These are about the range of values always obtained by weak acid extraction for this productive soil type. These values do not denote the fairly well-defined "available" phosphate as applicable to non-lateritic soils, but give a measure of the dynamic equilibrium that is reached between some fairly insoluble colloidal phosphate complex and that which passes into solution with standard strength and volume of week acids. As the initial soluble portion is removed from the system by an acid extracting medium or by the roots of plants, further, only slightly smaller, amounts of phosphate pass from the insoluble into the soluble phase by further extractions. The recorded relative values obtained during this initial standard extraction indicate both the amount of phosphate reserves and the continuous availability of phosphates in this soil type, provided that allowances can be made for changes in the organic matter content and soil reaction. When these latter values are raised, the amount of phosphate extracted by weak acids is increased. A single extraction with tenth-normal soda so dissociates the phosphate complex that in the same soil sample about 0.06 per cent phosphate is removed from the system or more than fifty times as (much as by a more prolonged fifth-normal acid extraction. Such a soda extraction removes more than half of the total soil phosphates, including added soluble phosphates that rapidly become fixed, but excluding most of the residues of unaltered, recently added, insoluble phosphates; the latter are soluble in weak acids. The quoted values for potash refer mainly to the so called "exchangeable potash", but in the case of the soil that has been newly enriched in organic matter and material of high ash content from the decaying litter, it is likely that some unabsorbed potash of organic origin is also extracted by this treatment.

A separate analysis of the uppermost ¾-inch layer of the enriched soil immediately below the litter of Plot 3 showed it to contain 63.1 p.p.m. phosphoric oxide and 3.41 M.E./100 g. or 0.160 per cent of potash. The very slow downward movement of phosphate in this soil type is illustrated by the high accumulation of this nutrient in the uppermost layer of the undisturbed soil.

Table III shows very marked increases in the "rate of availability" of phosphate and in the "available" potash in the surface soil under the cover crop. The increase of 9.4 p.p.m., i.e. from 9.9 to 19.3 p.p.m., of phosphoric oxide, equal to about 17 lb. per nine-inch acre, represents only a portion of the improved phosphate status. The acid-leaching treatment indicates the initial rate of availability of this nutrient rather than the available reserves which have also been increased. It is outstanding in that the surface soil has an improved phosphate status in spite of the extraction from the soil profile of about 100 lb. phosphoric oxide which is contained in the overlying cover crop and its litter. Phosphate has been removed from the fairly insoluble colloidal complex from the whole root zone and has been deposited in a more available form along with newly accumulated organic matter in the top-soil. The natural upward cycle of this nutrient to the surface via root action and plant debris has been hastened and, from the known very slow downward movement of phosphate in this lateritic soil type, the greatly improved phosphate status of the surface soil is likely to be prolonged. As this soil type is fairly low in total phosphates, it is likely that when worn-out arable land, with depleted phosphate reserves, is rested under such a leguminous or other cover, it would be an economical practice to broadcast and to work into the soil some finaly ground, cheap mineral phosphate or bonemeal to encourage such growth and to hasten the accumulation of more available phosphate in the surface soil.

The greater amount of exchangeable potash in the surface soil of the plot carrying the cover crop is most marked. This was confirmed by extracting with normal ammonium acetate. The value of 2.04 M.E./100 g. soil for Plot 3

is greater by 0.89 M.E./100 g. than that obtained for Plot 1. This represents a gain of 760 lb. potash per nine-inch acre if the soils were similar in this respect at the start of the experiment. This soil type is exceptionally rich in available potash; the values obtained for over a hundred representative surface soils range between 1.0 and 2.0 M.E./100 g., the higher values being usually associated with soils of coffee plantations which have had heavy dressings of organic manures. The values for the sub-soils are also correspondingly high. Added potash is generally not required and only where severe surface erosion has occurred is it likely that more potash will prove beneficial; in all such cases, the need for building up humus and phosphate reserves is very much greater.

Nutrient Content of Cover Crop and Associated Litter

The values quoted in Tables II and III refer to the nutrient status of the soils only and do not include nutrients contained in the standing legume and its litter. Representative samples of unit areas of the litter and also of the leaves and green stems of the cover-crop, omitting the basal coarser stems greater than about one-tenth of an inch in diameter, were weighed and analysed. The crop was estimated to amount to about 21,000 lb. of fresh green matter, or 5.700 lb. of dried matter, per acre; the litter, with some dispersed soil, to about 16,200 lb. of dry matter per acre. The latter contained 26 per cent of soil and insoluble ash, 13 per cent of soluble ash, and 61 per cent of organic matter as shown by the "loss on ignition" value. The soil-free and ash-free organic portion was calculated to amount to about 9,900 lb. per acre. The material was partly humified and served as an additional vegetable mulch underneath the growing cover crop. The composition and accumulation of nutrients in the crop and its litter are shown in Table IV.

The total nutrient contents of the cover crop and its litter amount to about 400 lb. of total nitrogen, about 100 lb. of phosphoric oxide and about 300 lb. of potash per acre. The mineral ingredients have been extracted from the whole soil profile and in due course when ploughed in will enrich the surface soil of the cover crop still further. Most of the nitrogen contained in material above ground level will at first be contained in the surface soil but, owing to nitrification and ultimate leaching, some unknown portion will soon be lost to the more or less stable soil nitrogen. When the surface cover is ploughed in the nutrient status of the surface soil is therefore enriched more than that shown by the comparative soil analyses quoted.

Assuming that no nitrogen is lost during the breaking down of the vegetal cover turned in, the surface soil is temporarily enriched by a further 400 lb. of nitrogen that has to be added to the increase of 1,164 lb. already recorded by soil analysis. When the cover is newly ploughed in, the total soil nitrogen would appear to be increased, for the time being, by a further 0.022 per cent, making a total of 0.292 per cent in 1941, against 0.206 per cent in 1932. The gain within nine years of 0.086 per cent, representing about 1,500 lb. nitrogen per nine-inch acre, is accompanied by a change in the soil from dark chocolate-red to almost black, with a much improved natural structure. Similarly, the inclusion of about 100 lb. of phosphoric oxide and about 300 lb. of potash contained in the surface organic matter would further increase the already heightened levels of these nutrients in the surface soil of the cover-crop plot.

Discussion

It will have been noted that this work originated from field observations on the markedly improved soil conditions in the old-established cover-crop plot as compared with the adjoining area under clean cultivation. The investigation was not a planned one. Hence the data on the

TABLE IV

Composition of Cover Crop and Litter

Lb. per Acre Earth-free Dry Matter	Percentage Composition of Dry Matter			Nutrient Content in lb. per Acre		
	Nitrogen	Phosphoric Oxide	Potash	Nitrogen	Phosphoric Oxide	Potash
Cover-crop: 5,700 ..	2·28	0·40	1·96	130	23	113
Litter: 12,000 ..	2·33	0·73	1·66	280	88	197
Total, 17,700 ..	—	—	—	410	111	310

original phosphate and potash status of the two plots are missing and more frequent sampling and analyses for all nutrients have not been done. In default of these use has been made of old analytical data collected for other purposes and further similar sampling and more detailed analyses have been made to measure the observed soil improvement. However, the changes, as confirmed by soil analyses, are so marked that the unavoidable limitations of the survey have not greatly lessened the value of the work and the results that can be drawn from it.

In this single instance it is clear that a cover of the indigenous legume *Glycine javanica* made a vigorous and prolonged growth and that within nine years it greatly raised the stored fertility of the Kikuyu loam at the Scott Agricultural Laboratories. Owing to the lack of proper comparative analytical data, the values for phosphate and potash are not necessarily accurate, but there is evidence that the surface soil has been greatly enriched in these nutrients. Total soil nitrogen has been raised from 0.206 per cent to 0.292 per cent, a gain of about 40 per cent and equivalent to an accumulation of about 1,500 lb. nitrogen per nine-inch acre within nine years, more than half of it during the first four. This equals the nitrogen contained in 60 or 70 tons of good compost. The total nitrogen in the soil-mulch plot appears to have been about constant during the period of weed growth, followed by a possible small loss during the subsequent five years under true soil-mulch. The cover crop is seen to have extracted from the whole soil profile very large amounts of nutrients, which are added to the surface soil when the crop is finally ploughed in previous to a further arable ley. This particular cover crop has been shown to be highly suitable as a means of conserving and improving the soil during resting periods and also previous to the planting and during the early stages of growth of widely spaced permanent crops.

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COMPOST-MAKING WITHOUT WATERING

Volume III, No. 3 (November, 1937) of the *E.A. Agricultral Journal* contains an article under the above title, setting forth a distinct advance in the technique of compost-making, and it treats of a successful method by which the making of compost is brought within the reach of those who hitherto have not been able to afford the chief requisite of the Indore process, i.e. large quantities of water.

The method takes advantage of the water content of freshly-cut elephant grass which is sufficient to compost the other materials used—boma manure and coffee pulp, but other materials such as dry grass and rubbish would, if added, probably defeat the effects of the elephant grass's moisture content.

A few years ago the writer, with the same non-watering idea in view, made a small amount of compost in a garden and used dry boma manure and dry grass and the crushed leaves of the *Opuntia* Cactus, known as Burbank's Spineless.

The large cactus leaves were roughly mashed with the end of a wattle pole; the whole leaves are so heavy that although they would have broken down in the process, might have made the heap too solid with a consequent defeat of the amount of aeration necessary.

The cactus, by reason of its 80 per cent moisture content, breaks down rapidly into a semi-liquid body which efficiently coats the fibres of the other materials.

The writer was unable to follow up this small experiment and kept no notes and had no analysis made, but if anything, the process was more rapid than that of the ordinary routine of his compost-making for coffee.

The use of this easily grown cactus, which will put up with poor soil, may suit some planters and enable them to do their composting adjacent to the areas to which the compost is to be applied and it makes available much other material which is near at hand.

C.M.B.

A SIMPLE "NO-WASTE" HYGIENIC FEEDING TROUGH FOR POULTRY

By E. S. E. Thompson, Veterinary Department, Tanganyika Territory.

Take two pieces of 2 in. by 2 in. timber, each 22 in. long, and 14 in. from the ends fasten another piece of 2 in. by 2 in., 24 in. long, so that the distance between the inside of the long pieces is 8 in. The protruding ends will then be 6 in. on either side. At 8 in. from the ends first measured fasten a piece of 2 in. by 1 in. by ½ in. This now forms one end support for the trough. Make a similar shaped piece for the other end. Nail a piece of timber 3 ft. by 7 in. by ½ in. to the cross members leaving ½ in. clear between each leg and the board. (The width of 7 in. may vary according to the thickness of timber used. For example, if ¾ in. timber is used, the board will be only 6½ in. as the clearance between board and leg is to allow for the sides of the trough being slipped into place. The construction details will be given assuming ½ in. timber is used, as this thickness has been found to be sufficient for the purpose.)

Take two pieces 3 ft. by 8 in. by ½ in. for the side pieces of the trough, and fasten lightly to the inside of the legs.

Take two more pieces 12 in. by 8 in. by ½ in. for the ends, and nail lightly to the outsides of the legs.

Nail through the ends to the sides and then withdraw the nails which were used to hold each piece lightly in position. The body of the trough can be now slipped down over the base or removed as required.

The removable hopper top is made from two pieces 12 in. by 6 in. by ½ in. for the ends and two pieces 3 ft. by 6 in. by ½ in. for the sides. These sides are fastened so that the lower edges are 2 in. apart and 2 in. from the bottom of the end pieces. A strip 12 in. by 2 in. by ½ in. is fastened to the outside of either end so that the top cannot be pushed off.

The side platforms are made 32 in. by 8 in. by ½ in., and fastened to a piece of 8 in. by 2 in. by 2 in. at either end. These platforms fit between the legs and rest on the protruding ends of the crosspieces, but are not fastened.

The advantages of the trough are—

- Easy removal of all parts for cleaning, yet maintaining a firm structure when in use.
- The birds can take all the food they require but cannot scratch the food out. (A saving of at least 10 per cent on food issued to pens using this trough has been obtained.)
- The birds cannot soil the food.
- The trough is cheap and simple to make.

It may be noted that birds of the air do not enter the trough so readily as they do one with an open top lying on the ground.

All the dimensions given in these constructional details may be varied to suit the type of timber available locally. The important point is to make the body of the trough a good fit over the base. This ensures easy removal and no leakage of food between sides and base.

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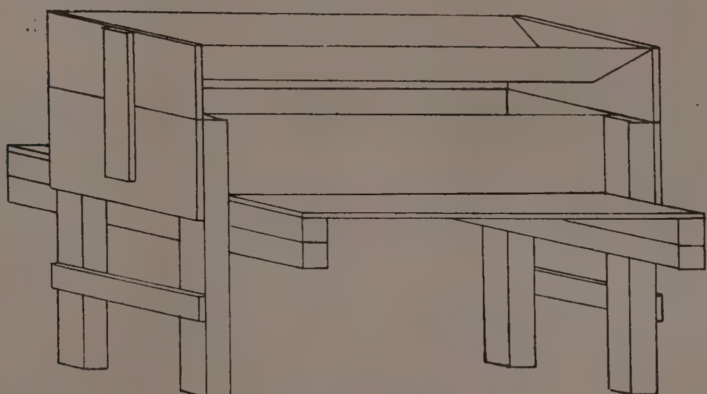

ISOMETRIC VIEW

MUCK AND MAGIC: A REJOINDER

By Sir Albert Howard, C.I.E.

(Formerly Imperial Economic Botanist to the Government of India, Director of the Institute of Plant Industry, Indore, and Agricultural Adviser to States in Central India and Rajputana)

In the issue of the *E.A. Agricultural Journal* of January, 1941 (Vol. VI, No. 3, p. 139), an article appears under the above title and over the initials T.W.K., in which the writer calls in question my views on humus as set out in *An Agricultural Testament* and other papers. I should like very briefly to reply to these criticisms which amount to this: (1) the virtues of humus have been so exaggerated that my statement of the case is hampering progress; (2) my ideas on the relation between insects and fungi and the plant diseases with which they are associated are unsound; (3) the synthesis of humus taking place on the floor of the forest is not a safe guide for the farmer; (4) my knowledge of artificial manures begins and ends with nitrate of soda.

1. The proof of the pudding is in the eating. I wish I could take T.W.K. with me on the magic carpet round the world to see for himself the revolution in agriculture which is in progress and to hear what my thousand and odd correspondents have to say about the virtues of freshly prepared humus when made by the Indore process. All this development is based not on exaggerated claims but on the one unanswerable argument—success. He would, I think, on this pilgrimage find little or no evidence for the view that my statement of the case is hampering progress. It could hardly be more rapid or more satisfactory.

2. In *An Agricultural Testament* (p. 169), I summed up my experience of disease in the following words: "I have examined in great detail for forty years the principles underlying the treatment of plant and animal diseases, as well as the practice based on these principles.

"There can be no doubt that the work in progress on disease at the experiment stations is a gigantic and expensive failure, that its continuance on present lines can lead us nowhere and that steps must be taken without delay to place it on sounder lines.

"The cause of this failure is not far to seek. The investigations have been undertaken by specialists. The problems of disease have not been studied as a whole, but have been divorced from practice, split up, departmentalized and confined to the experts most conversant with some organism associated with the disease.

"This specialist approach is bound to fail. This is obvious when we consider (1) the real problem—how to grow healthy crops and how to raise healthy animals, and (2) the nature of disease—the breakdown of a complex biological system, which includes the soil in its relation to the plant and the animal. The problem must include agriculture as an art. The investigator must therefore be a farmer as well as a scientist, and must keep simultaneously in mind all the factors involved."

Growers in many parts of the world have confirmed the soundness of these views. They find the best way to prevent insects and fungi damaging crops is to restore the fertility of the soil, to grow suitable varieties, and to pay attention to the details of soil management.

The case of the silkworm and the mulberry on which T.W.K. bases one of his arguments has no relation whatsoever to agriculture. Silk is not a crop in the ordinary sense. The rearing of the worms is purely artificial; they do not feed on the growing leaves but on picked foliage which is constantly changed. The developing silkworms are tended with perhaps even more solicitude than is bestowed on the majority of infants. Unless the greatest care is taken in the raising of the eggs there would soon be no silk industry at all. The parasites would destroy them in a very few years. If a grove of well-cultivated mulberry trees were inoculated with silkworms, I am confident, from what I saw of the silk industry in Kashmir, the amount of fibre produced under natural conditions would soon bear no relation to what would be obtained when the leaves are taken to a rearing house and the insects carefully tended. The silkworm, left to nature, would soon disappear.

3. The reason given in the article under discussion why the synthesis of humus on the floor of the forest is not a safe guide for agriculture is that serious damage by insects and fungi has occurred in the forests of the United States. That the management of both agricultural and forest land in that country leaves much to be desired and furnishes an example of what to avoid rather than to copy will be clear from a study of the 1938 Year Book of the United States Department of Agriculture, entitled *Soils and Men*. By 1937, as a result of long-continued

mismanagement, no less than 253,000,000 acres, or 61 per cent of the area under crops, had either been completely or partly destroyed or had lost most of its fertility. In all cases the cause was traced to soil erosion; in other words, to Nature's reply to the operations of the bandits of agriculture and of forestry. As is well known, the soils of many parts of Africa are also on the down grade for reasons similar to those which have been in operation in the United States.

Insects and fungi occur everywhere in Nature but only do serious damage to crops when some factor intervenes which profoundly affects their growth and development. Often the causes of such disease are man-made; cases, however, occur when the trouble is due to some natural cause such as too much or too little rain.

4. On the use of artificials in agriculture and their effect on the crop, I summed up in my recent book the results of over forty years' close study and practical experience of this subject carried out in four continents—Europe, Asia, Africa and America—in the following words: "The slow poisoning of the life of the soil by artificial manures is one of the greatest calamities which has befallen agriculture and mankind. The responsibility for this disaster must be shade equally by the disciples of Liebig and by the economic system under which we are living. The experiments of the Broadbalk field showed that increased crops could be obtaineed by the skilful use of chemicals. Industry at once manufactured these manures and organized their sale." These words were not written without a great deal of practical experience and much experimental work. This included a study of the mycorrhizal relationship, a newly discovered factor which is certain to relegate the current views on artificial manures to the lumber-room of exploded ideas.

In conclusion I should like to make one suggestion which, if accepted would do much to make future discussions on humus in agriculture more interesting and more useful. Participants should base their views either on a combination of experience and experiment or on experience only. In this way the discussion can be kept on solid ground. They should above all things avoid basing their arguments on mere snippets of literature culled from agricultural journals or on some single fact or phenomenon isolated from its setting. No more unsound foundations for argument exist than are to be found in the literature of agricultural science largely based as it is on small plot experiments unconfirmed by long practical experience. Single facts and isolated phenomena provide little more than puzzles when divorced from their attendant circumstances. By a judicious selection of fragments such as I have indicated it is possible to prove or disprove anything or everything. Over forty years ago, when I was on the staff of the Imperial Department of Agriculture for the West Indies, it was one of my distasteful duties to prepare notes for publication based on literature and on the results of laboratory and plot experiments. None of this information was ever tried out on the land. The result was the publication of papers which could justly be described as mere impertinences of ignorance. The contribution under discussion suggests that similar weaknesses still persist in our Colonial Agricultural Departments.

[The foregoing is published without comment. Sir Albert Howard remarks in a covering letter that he "cannot allow injustice, unfairness in any form to pass unnoticed".—*Ed.*]

Many years ago Jethro Tull told us that "Tillage is Manure", a maxim that should be remembered and put into use now. Proper soil management, proper cultivation of the soil and adequate ploughing, all serve to aid in the maintenance of soil fertility. The rotation of crops, the inclusion of a legume in the rotation, the avoidance of too many inter-tilled crops planted in rows, the inclusion of crops completely covering the soil—in which pastures laid down for a few years may be included—are items of soil management that help to maintain fertility and crop yields.

Extract from *Farming in South Africa*, Vol. XVI, p. 310, 1941.

Marxists are right in maintaining that science has never achieved perfect objectivity. But there has been a brave, determined, continuous, and on the whole successful effort to strip scientific investigation and theorizing of emotional and of personal predilections. Democracy flounders before it arrives at a satisfactory solution of its social problems, but it is better to flounder and progress than to follow the philosophy of a dictator and remain socially and scientifically static. Under a totalitarian regime science may indeed exist, but it will become frozen as art and science were in ancient Egypt.

Nature, 10-5-41.

NOTES ON ANIMAL DISEASES

XV—CONTAGIOUS BOVINE PLEURO-PNEUMONIA

Compiled by the Veterinary Department, Kabete, Kenya

Contagious bovine pleuro-pneumonia is a specific disease of cattle caused by an exceedingly small micro-organism, *Asterococcus mycoides*. For many years the causal agent was believed to be a virus, since it passes through many of the filters which stop ordinary bacteria. The organism can, however, be grown on lifeless laboratory media, and by the use of special techniques it can be seen with a microscope fitted with high-powered lenses. The disease occurs only in cattle.

Until the last decade all attempts to reproduce the disease by inoculating cattle with fluid from infected lungs or with cultures failed. On subcutaneous inoculation both materials produce a local "tumour" and fluid from the "tumour" will cause a further "tumour" on subcutaneous inoculation to another beast, but infection of the lungs is not produced.

In 1932 a typical case of lung infection was produced at Kabete in one out of 16 animals by inoculating filtered lung exudate into the windpipe of susceptible cattle. Special precautions were taken at the time of inoculation to prevent the infective material entering the tissues at the site of the needle puncture. Further experiments showed that the disease could be almost regularly reproduced by inoculating into the vein material incorporated in semi-solid plugs of agar. Special precautions to prevent infection at the site of inoculation were again found to be necessary for it is very unusual for lung infections to be established if a local swelling is produced.

More recently Australian workers have shown that an animal may be infected by placing the head in a box, in which a fine spray of either infective lung fluid (known as "lymph") or an early generation of culture is produced by atomizing the liquid into the box. These observations on experimental infection have been confirmed at Kabete.

Under natural conditions the disease is contracted by inhalation of the causal organisms that have been coughed up as a fine spray by infected animals.

Contagious bovine pleuro-pneumonia is essentially a disease of dry countries, although it occurs, or has occurred, in most parts of the old world.

Incubation Period.—This is usually 3–6 weeks; but a period as short as 10 days or as long as 10 weeks between contact with infected animals and the first appearance of symptoms has been reported. Usually the disease spreads slowly in an infected herd, but on occasion, quite rapidly.

Symptoms.—Cases may be peracute, acute or subclinical. The peracute form in which the pneumonia lasts but a few days is uncommon.

The acute form is the most frequently seen. In the early stages there is a rise in temperature, the animal appears dull, the coat is rough and there is disinclination to feed. Later, typical symptoms appear, a cough at first dry and painful, subsequently moist, laboured breathing and grunting expiration. The animal stands with the elbows turned outwards and the head extended to relieve pressure on the chest, almost invariably facing into the wind and with nostrils dilated. In the later stages there may be a mucopurulent discharge from the nose and sometimes an oedematous infiltration of the lower part of the chest. Flesh is lost rapidly and finally the animal lies down.

In fatal cases death occurs 2–3 weeks after the onset of symptoms. A large percentage of affected animals make a partial and eventually a complete recovery. Condition is regained particularly if grazing and weather are favourable; but infection may persist in the affected part of the lungs for a period of several months. Such animals remain a potential source of infection and are called "lungers".

In the sub-clinical form, symptoms are less marked and usually escape observation.

Swellings at the joints are sometimes seen in young calves.

Post-mortem Lesions.—These depend upon the stage at which the animal dies or is killed, and upon the type of the infection. In the ordinary acute case infection is usually restricted to one lung. On opening the chest, the pleural cavity on the affected side is found to contain a varying quantity of straw-coloured or reddish exudate in which are floating yellowish flecks and strands of fibrin. On standing the exudate clots. The affected part of the lung is usually affixed to the chest wall by a yellow, spongy mass of tissue.

The diseased lung-tissue does not collapse but appears raised above the relatively more normal portions. It is solid, and the freshly-cut surface has a marbled appearance, areas of pink, dark red and grey lung-tissue being marked off by yellowish veins of varying width. On close examination the veins, which are the thickened tissue partitions which

separate the lobules of the lungs, show a beaded appearance, the lymph spaces, round, oval or elongate in shape, being distended with lymph. On standing, a clear yellow exudate, which clots on exposure to the air, will exude from the cut surface.

At a later stage the interlobular tissue consists of firm connective tissue, while the lobules lying between are either dark grey or brown in colour, or, if they have become necrotic, sometimes yellowish. Still later, in animals that are recovering, it is usual to find the affected portion of the lung enclosed in a thick fibrous capsule. The encapsuled portion, which may vary in size from that of a pea to a large orange, is known as a "sequestrum". Eventually even this may be absorbed, or it may become liquefied and appear like an abscess. In many old cases of pleuro-pneumonia the only evidence of past infection may be the thickened pleura and firm adhesions between lung and chest-wall, together with thickening of the fibrous septa of the lung in the area adjacent to the adherent pleura.

Differential Diagnosis.—During life it is difficult to distinguish cases of contagious bovine pleuro-pneumonia from cases of pneumonia and pleurisy of other origin. Post-mortem, however, the naked-eye appearance of the lung lesions is usually sufficient to enable a definite diagnosis to be made. A form of hæmorrhagic septicæmia known as "cornstalk disease" occasionally gives a very similar lung lesion; but this acute pneumonic form is very rare in Kenya and a microscopical examination of sections of preserved lung will enable a distinction to be made. Occasionally the lung of an animal dead of east coast fever may deceive the unexperienced observer. A specimen of lung preserved in glycerine together with another specimen in formalin should be dispatched to the laboratory for examination, the one for isolation of the organism and the other for histological examination.

At Kabete and elsewhere years of work have been devoted towards the elaboration of a reliable serological test for the detection of "lungers" or other infected animals. At the moment, a fairly satisfactory test is available; but, since it depends on the presence of immune bodies in the serum, it tends to pick out animals which have recently recovered from infection and vaccinated animals as well as those in which infection still persists.

Vaccination.—A vaccine is prepared at the Kabete Laboratory and there is no doubt that this vaccine evokes a very good degree of immunity compared with many other bacterial vaccines. During the last four years hundreds of thousands of doses of the vaccine have been used by the Northern Rhodesia Veterinary Department in the Barotse Province, where the disease had been enzootic since 1914 and where the cattle population had been reduced. Pleuro-pneumonia has now been almost exterminated, a few cases only being reported each year, and the cattle population has increased to such an extent that it has become necessary to explore new outlets for the surplus animals. The vaccine has also been used with complete success over large tracts of clean territory in Bechuanaland.

The vaccine consists of a live culture which has been attenuated by serial passage in laboratory media. Formerly a strain was usually considered safe for use for the first inoculation of the tail when in the 25th-35th generation. A vaccine for the second inoculation in the tail or the final injection in the shoulder was usually of the 19th-25th generation.

Unfortunately, the use of these vaccines is liable on occasion to cause heavy reactions and the cause for these vaccine breaks is not understood. A strain of vaccine which has been used with safety for ten or more generations on thousands of cattle may suddenly produce abnormally severe reactions and death in as many as 10 per cent of the inoculated animals. In some cases the batch after that producing serious reactions has been shown to be of normal low virulence. Such severe reactions are commoner in already infected herds.

At present vaccine for the first inoculation is being issued at the 60th to 80th generation and occasional breaks have occurred even with cultures as mild as this. Efforts are being made to discover the cause of this sudden enhancement in virulence; but for the moment it has not been possible to devise any method by which the change can be detected before the vaccine is actually inoculated to large numbers of animals in the field. In spite of the risk it is necessary to continue the use of vaccine as it is. The overall mortality in vaccinated cattle is less than 1.5 per cent, and the vaccine is certainly less dangerous than attempting to immunize by any of the older methods. Where severe reactions occur much can be done to reduce mortality by prompt treatment of severe reactors. In cases where the reaction swelling tends to extend upward to the root of the tail, cauterization with a hot iron around the tail above the swelling is recommended. When this method of treatment is carried out promptly and skilfully the loss of a great many animals may be saved even though tails are lost.

CORRESPONDENCE

"Dornie", c/o Poste Restante,
Nakuru, Kenya.
8th May, 1942.

The Editor, East African Agricultural Journal,
Amani, via Tanga, Tanganyika Territory.

Sir,

I have read with great interest in your issue for last month Mr. Maher's views on African Labour on the Farm in Kenya Colony. As was to be expected, they are reasonable and fair, yet it would be surprising if every farmer accepted them all: I have some comments to offer.

I disagree entirely with the suggestion that labourers should be encouraged to keep chickens: such a practice would be a direct incentive to the theft of poultry, eggs and fowl-food from the employer and would surely lead to the introduction of fowl disease. Parenthetically, the keeping of pure-bred poultry in good runs by the employer is not a solution.

Mr. Maher is insistent upon the employer's duty to provide an ample supply of good, clean water: here I find myself in sympathy with him, but I feel he has not probed far enough. Naturally, my own case comes first to my mind. My farm is on a plain almost at the end of a very small permanent stream. An Ordinance (I think one of the Crown Lands Ordinances) confers on riparian landowners the right to water stock in rivers, provided no interruption is made in the flow of the river. For long stretches of "my" river the one is not possible without the other, and one result is that never do my labourers, my stock or I get any but the foulest water. Over many years I have endeavoured to get the Water Authority to recognize those facts and realize that, apart from voluntary co-operation, no amelioration is possible with the law as it stands to-day: up to now neither the co-operation nor the change of law has been forthcoming, and "my" river remains a sewer. Mr. Maher's suggestion of piped dams or bore-holes would, I submit, have carried much greater weight if he had treated them in a similar manner to that of the subsidized housing in the second column of page 231. For some years I have been ready to have a bore-hole, if the cost could have been discharged by an addition to my rent, but, so far as I am aware, no reasonable scheme on those lines has been adopted by Government.

In the matter of housing, I feel I have done my servants pretty well, but I am beginning to wonder how long the feeling will last. About a year ago I built a block of quarters for casual labourers: these were furnished with beds, and doors with hinges and locking devices. Since then some of the beds have been torn out, most of the hinges have gone and not a single lock remains. I admit I have been a great deal away from home on other work and that a woman (my wife) has to approach such acts of indiscipline with greater circumspection than a man: nevertheless respect for others' property is not an outstanding part of African character, and treating the lack of it as "a breach of farm discipline, and punishable as such", a suggestion in the second column of page 223 will not meet with the approval of every magistrate should a sophisticated labourer carry his grievance there.

I am, Sir,
Your obedient servant,
ANGUS MACDONALD.

Man's control of his own future may depend in the long run on whether his biological knowledge, which is constructive, can catch up with his knowledge of the physical sciences, which has taught him so much about how to destroy.

H. A. Wallace in *United States Department of Agriculture Year Book*, 1937.

It is not sufficient merely to use science to solve problems that are seen to exist. What is much more important is to use science to discover what the problems are and what is their order of importance.

Science in War.

INDUSTRIAL USES OF CASHEW AND ITS PRODUCTS*

Introduction

The cashew (*Anacardium occidentale* L.) has of late received commercial importance chiefly on account of the great demand for its edible kernels. Believed to be a native of South America, the cashew that was introduced on the west coast of India by the Portuguese has now established itself as a commercial crop in the States of Cochin and Travancore and in the district of Malabar and South Kanara. It is now seen to be spreading to other parts of the Presidency, on account of its capacity to thrive under widely varied conditions of soil, climate and rainfall. The possibilities of further extension in its cultivation in regard to its occupation of land now left uncultivated due to subnormal fertility, indifferent rainfall, or other reasons, cannot be under-rated.

The importance of the cashewnut in industry can easily be gauged when we note that, according to the latest available figures, about 10,192 tons of cashew kernels valued at Rs. 11,411,170 were exported from British India during the year 1936-37. Of this, S. India contributed 8,799 tons, valued at Rs. 9,971,567, while Bombay was responsible for the remainder. The value of exported cashewnut kernels from India is about 82 per cent of the world export trade in them, which amounted to 3½ million American dollars in 1936 (i.e. about 14 million rupees).

Commercially to-day, the cashew kernels alone are known to any extent. The cashew, however, yields certain other products, each of which foster possibilities of industrial utilization. Though the economic uses of these products have been established, they form as yet only a fertile field of unexplored wealth. This note collates the already recorded uses to which the products of cashew can be put, and it is hoped that it would stimulate interest both in regard to the extended cultivation of cashew and its increased industrial use.

The Cashewnut

The cashew is chiefly cultivated for the valuable kernels that it yields. In India the cashew kernels, both "raw" and "roasted", find a place in a variety of household preparations. In Europe and America the kernel is largely used as a dessert nut and for making confectioneries, particularly in the manufacture of nut chocolates. It provides a cheap source of protein and is considered better than other nuts because of its high biological value. Table I below gives a comparative statement of the protein content, true digestibility and biological value of cashew and other commercial nuts.

TABLE I

Protein Content, True Digestibility and Biological Value of Cashew and other Nuts*

Description of Nuts	Protein Per cent crude	True digestibility	Biological value
Cashew nut, fresh	19·52	96·23±0·16	72·50±0·66
Blanched almonds	21·94	93·95±0·23	50·84±0·37
English walnuts, fresh	21·16	84·11±0·22	55·89±0·92
Groundnut, raw..	28·25	97·39±0·27	57·90±1·1

*From Mitchell, and Readless (1937)

The cashewnut is also said to contain vitamins A and B. It contains about 40 per cent of oil of high nutritive value equal to that of almond oil and superior to olive oil. The oil, it is reported, can be utilized with advantage in certain pharmaceutical preparations. It is not of much interest commercially at present, as the price of the kernels is too high to be utilized for production of oil.

In spite of all these advantages, the cashew kernel is marketed in India in a very indifferent manner. No proper grading or hygienic packing of the stuff is undertaken in the internal markets though some attempt in this line is made with the stuff exported. Joachim (1936), in his studies in the "Vita-pack" process for preserving cashewnuts, has found that the packing of well-dried cashewnuts in well-sealed receptacles containing dry carbon dioxide gas is a very effective means of preserving them for no less than eight months (the duration of the experiment). The trials also appear to indicate that, provided that the nuts are thoroughly dried, they can be preserved for this period of time in well-filled and well-sealed containers without carbon dioxide. An organized production, grading, packing and marketing would thus certainly induce

* By C. M. John, Oil Seed Specialist, Coimbatore, in *The Madras Agricultural Journal*, Vol. XXIX, No. 5, May, 1941.

A fuller study on this subject appeared in *Agriculture and Livestock in India*, Vol. 9, No. 1, pp. 26-41, under the title "Development of the cashewnut industry in India."

greater utilization of the produce in the confectionery trade and better sales both in the home and foreign markets.

The Shell

The cashewnut shell contains 29 per cent of a reddish-brown oil, of which 10 to 15 per cent is obtained during the roasting of the nuts, which is commonly done in open pans over a small circular earthen furnace. As nuts get roasted the oil exudes out and is drawn off at one end. The oil contains anacardic acid, gallic acid and cardol. The shell oil finds extensive use in the preparation of varnishes, synthetic resins, moulding compositions, insulating coating, inks, etc., as a preservative paint for boats and fishing nets, and as a protective for floors and wooden rafters against termite attack. The acrid oil is medicinal, and "has been used as an anæsthetic in leprosy and as a blister in warts, corns and obstinate ulcers". In combination with kerosene or crude oil, it is lethal to mosquito larvæ. In addition to these uses, further interest in anacardic acid, which forms 90 per cent of the corrosive oil, has arisen recently as an antiseptic for textiles, the anilide and analogous derivatives of the acid being expected to combine the antiseptic properties of "shirlan" with a wetting power from its polar hydroxyl and hydrophobic long chain alkyl residue.

It is estimated that about 11,000 gallons of this oil are annually exported to Europe and particularly to America under the trade name of "Cardole oil". The price of the oil varies from 8 to 12 annas per gallon. It is also computed that "about 32,000 tons of raw cashewnuts are roasted every year in India and thus at the present rate of kernel production nearly 13,000 tons of roasted shells containing nearly 18 per cent of oil are available which could yield 53,000 gallons of the roasted nut shell oil". It may be possible to improve the process of roasting with a view to greater recovery of the oil.

The cashewnut shell is at present largely used as fuel in the process of roasting the nuts. The partly burnt shells from a previous charge form the fuel for the next charge of nuts. This method is wasteful, for the shell is valuable for other purposes. It gives on destructive distillation a combustible gas of a calorific value which compares favourably with coal gas. A ton of cashew shells gives about 6,000 cubic feet of gas. The shell charcoal, which is one-third of the shell, has a calorific value of coal and is smokeless.

The Cashew Apple

The apple, which is the swollen pedicel of the fruit, is edible and on a small scale is eaten fresh or preserved with sugar. It has antiscorbutic properties, containing as it does vitamin C. It is determined that 1 oz. of the fruit contains 120 milligrams of vitamin C, and the normal requirement for a man is 50 milligrams. By fermentation, either alcohol or vinegar can be obtained from it. "Dr. F. Marsden finds that 100 gms. of the apple yields 70 c.c. of juice, containing 11.2 grams of invert sugar and on an average 3.8 per cent of alcohol." The invert sugars of the apple are valuable for inclusion in infant and invalid foods. These can be made available by converting the juice of the apple into a syrup which preserves the invert sugars. When mixed with iron sulphate the juice is said to make a good hair dye.

The cashew apple thus should be given further attention. An attempt should be made to utilize this fruit in the different ways indicated above instead of allowing it to be wasted. Preservation of the apples, particularly of the sweeter varieties, in sugars can be organized as a cottage industry.

The Cashew Wood

Cashew timber is used for making country boats and packing cases. The wood is red, moderately hard, close grained and weighing 38 lb. to the cubic foot. The resinous gum which exudes from the bark of the tree is said to be deterrent to insects, and can therefore be used for bookbinding. It is also useful in tanning. The sap obtained from the incisions in the bark is utilized as an indelible marking ink. The charcoal of the wood is highly estimated by the iron smiths of *Tavoy* and West Coast.

Conclusion

These are but a few of the many and diverse uses to which cashew and its products can be put. Many of them easily lend themselves to industrial exploitation. More than that, the products of cashew can replace many of the materials that are at present of necessity being imported into this country. Where India could be self-sufficient in its needs of small-scale industries, by the utilization of the wealth that is so easily procurable, cashew has abundant potentialities. A little more research on the side of industrial utilization of the different products should put the cashew industry of India on a sound basis for fuller expansion.